03-02- JC09 Rec'd PCT/PTO 28 FEB 2001 PCT

PTO-1390 U S DEPARTMENT OF COMMERCE / TENT AND TRADEMARK

(Rev. 11-2000)

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. § 371

ATTORNEY'S DOCKET NUMBER	
422852000800	
U.S. /	09/786623 To be assigned

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/IL99/00495	September 9, 1999	September 10, 1998

TITLE OF INVENTION

METHODS AND APPARATUS FOR ODOR REPRODUCTION

APPLICANT(S) FOR DO/EO/US

Eliezer FISCH, Sagit FINK, David HAREL and Doron LANCET

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☐ This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below.
4. ☐ The US has been elected by the expiration of 19 months from the priority date (PCT Article 31).
5. ☐ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. ☒ is attached hereto (required only if not communicated by the International Bureau).
   b. ☐ has been communicated by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☐ An English language translation of the International Application under PCT Article 19 (35 U.S.C. 371(c)(2)).
   a. ☐ is attached hereto.
   b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4).
7. ☐ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3)).
   a. ☐ are attached hereto (required only if not communicated by the International Bureau).
   b. ☐ have been communicated by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☒ have not been made and will not be made.
8. ☐ An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ An English language translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

OIPE JC106 FEB 2 8 2001 PATENT & TRADEMARK OFFICE

Items 11. to 16. below concern document(s) or information included:

11. ☐ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☒ A FIRST preliminary amendment (7 pages).
14. ☐ A SECOND or SUBSEQUENT preliminary amendment.
15. ☐ A substitute specification.
16. ☐ A change of power of attorney and/or address letter.
17. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825.
18. ☐ A second copy of the published international application under 35 U.S.C. 154(d)(4).
19. ☐ A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).
20. ☒ Other items or information: return receipt postcard,

CERTIFICATE OF MAILING BY "EXPRESS MAIL"

Express Mail Label No.: EM056842687US Date of Deposit: February 28, 2001

I hereby certify that this paper or fee is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 C.F.R. § 1.10 on the date indicated above and is addressed to: Assistant Commissioner for Patents, Washington, D.C. 20231.

Tatania Grollman

U.S. APPLICATION NO. (if known, see 37 CFR 1.5) To be assigned 09/786623	INTERNATIONAL APPLICATION NO PCT/IL99/ 00495	ATTORNEY'S DOCKET NUMBER 422852000800

21. ☐ The following fees are submitted:

BASIC NATIONAL FEE (37 CFR 1.492(a)(1)-(5)):

Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO.....$1,000.00

International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO.....$860.00

International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO.....$710.00

International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provision of PCT Article 33(1)-(4) $690.00

International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4) $100.00

	CALCULATIONS PTO USE ONLY	
ENTER APPROPRIATE BASIC FEE AMOUNT =	$860.00	
Surcharge of **$130.00** for furnishing the oath or declaration later than ☐ 20 ☒ 30 months from the earliest claimed priority date (37 CFR 1.492(e)).	$130.00	

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total claims	55 - 20 =	35	x $18.00	$630.00	
☐ Independent claims	6 - 3 =	3	x $80.00	$240.00	
☐ MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ $270.00	$0	
TOTAL OF ABOVE CALCULATIONS =				$1860.00	
☐ Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by ½.				$0	
SUBTOTAL =				$1860.00	
Processing fee of **$130.00** for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(f)). +				$0	
TOTAL NATIONAL FEE =				$0	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00 per property** +				$0	
TOTAL FEES ENCLOSED =				$1860.00	
				Amount to be refunded:	**$0**
				charged:	**$1860.00**

a. ☐ A check in the amount of $0 to cover the above fees is enclosed.

b. ☒ Please charge my **Deposit Account No. 03-1952** in the amount of $1860.00 to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees that may be required, or credit any overpayment to **Deposit Account No. 03-1952**. A duplicate copy of this sheet is enclosed.

d. ☐ Fees are to be charged to a credit card. **WARNING:** Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

Robert K. Cerpa
Morrison & Foerster LLP
755 Page Mill Road
Palo Alto, California 94304-1018

SIGNATURE

Robert K. Cerpa
Registration No. 39,933

PATENT
Docket No. 422852000800

CERTIFICATE OF MAILING BY "EXPRESS MAIL"

Express Mail Label No.: EM056842687US Date of Deposit: February 28, 2001

I hereby certify that this paper or fee is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 C.F.R § 1.10 on the date indicated above and is addressed to: Assistant Commissioner for Patents, Washington, D.C. 20231.

Tatania Grollman

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In the application of:

Eliezer FISCH et al.

Serial No.: To be assigned

International Application No: PCT/IL99/00495

International Filing Date: September 9, 1999

For: METHODS AND APPARATUS FOR ODOR REPRODUCTION

Examiner: To be assigned

Group Art Unit: To be assigned

PRELIMINARY AMENDMENT

Box Patent Application
Assistant Commissioner for Patents
Washington, D.C. 20231

Dear Sir:

Prior to examination on the merits, Applicant respectfully requests entry of this Preliminary Amendment for the above-captioned patent application before fees are calculated.

In the Claims:

Please substitute claims 17-25 and 35-43 with the following clean set of claims.

17. (Amended) The system according to claim 14 and wherein said trigger applies at least one of heat energy, light energy and mechanical energy.

18. (Amended) The system according to claim 14 and wherein said trigger comprises a scratch implement.

19. (Amended) The system according to claim 14 and wherein said odorant site has a property of locally rupturing upon application of said predetermined level of energy.

20. (Amended) The system according to claim 14 and wherein said odorant site has a permeability which increases upon application of said predetermined level of energy.

21. (Amended) The system according to claim 14 and wherein said trigger comprises a laser which produces a beam of laser radiation and directs said beam onto the odorant site.

22. (Amended) The system according to claim 14 and wherein said odorant sites are mounted on a substrate, and said odorant output device further comprises a motion device connected to said substrate which moves said substrate with respect to said trigger so as to selectively align one of said odorant sites with said trigger so that said trigger selectively applies said predetermined level of energy to said odorant sites.

23. (Amended) The system according to claim 14 and wherein said odorant sites are mounted on a substrate, and said odorant output device further comprises a motion device connected to said trigger which moves said trigger with respect to said substrate so as to selectively align one of said odorant sites with said trigger so that said trigger selectively applies said predetermined level of energy to said odorant sites.

24. (Amended) The system according to claim 14 and comprising a controller connected to said trigger which controls to which of said odorant sites said trigger selectively applies said predetermined level of energy.

25. (Amended) The system according to claim 14 and comprising a fan which creates a flow of air over said odorant sites.

35. (Amended) The odorant output device according to claim 32 and wherein said trigger applies at least one of heat energy, light energy and mechanical energy.

36. (Amended) The odorant output device according to claim 32 and wherein said trigger comprises a scratch implement.

37. (Amended) The odorant output device according to claim 32 and wherein said enclosure has a property of locally rupturing upon application of said predetermined level of energy.

38. (Amended) The odorant output device according to claim 32 and wherein said enclosure has a permeability which increases upon application of said predetermined level of energy.

39. (Amended) The odorant output device according to claim 32 and wherein said trigger comprises a laser which produces a beam of laser radiation and directs said beam on the enclosure.

40. (Amended) The odorant output device according to claim 32 and wherein said odor sites are mounted on a substrate, and said odorant output device further comprises a motion device connected to said substrate which moves said substrate with respect to said trigger so as to selectively align one of said odor sites with said trigger so that said trigger selectively applies said predetermined level of energy to said odor sites.

41. (Amended) The odorant output device according to claim 32 and wherein said odor sites are mounted on a substrate, and said odorant output device further comprises a motion device connected to said trigger which moves said trigger with respect to said substrate so as to selectively align one of said odor sites with said trigger so that said trigger selectively applies said predetermined level of energy to said odor sites.

42. (Amended) The odorant output device according to claim 32 and comprising a controller connected to said trigger which controls to which of said odor sites said trigger selectively applies said predetermined level of energy.

43. (Amended) The odorant output device according to claim 32 and comprising a fan which creates a flow of air over said odor sites.

REMARKS

Attached hereto is a marked-up version of the changes made to the claims by the current amendment. The attached page is captioned "**Version with markings to show changes made**".

In the unlikely event that the transmittal letter is separated from this document and the Patent Office determines that an extension and/or other relief is required, applicant petitions for any required relief including extensions of time and authorizes the Assistant Commissioner to charge the cost of such petitions and/or other fees due in connection with the filing of this document to **Deposit Account No. 03-1952** referencing docket no. 422852000800. However, the Assistant Commissioner is not authorized to charge the cost of the issue fee to the Deposit Account.

Respectfully submitted,

Dated: February 28, 2001 By: _____

Robert K. Cerpa
Registration No. 39,933

Morrison & Foerster LLP
755 Page Mill Road
Palo Alto, California 94304-1018
Telephone: (650) 813-5715
Facsimile: (650) 494-0792

VERSION WITH MARKINGS TO SHOW CHANGES MADE

In the Claims:

17. (Amended) The system according to [any of claims 14-16] claim 14 and wherein said trigger applies at least one of heat energy, light energy and mechanical energy.

18. (Amended) The system according to [any of claims 14-16] claim 14 and wherein said trigger comprises a scratch implement.

19. (Amended) The system according to [any of claims 14-16] claim 14 and wherein said odorant site has a property of locally rupturing upon application of said predetermined level of energy.

20. (Amended) The system according to [any of claims 14-16] claim 14 and wherein said odorant site has a permeability which increases upon application of said predetermined level of energy.

21. (Amended) The system according to [any of claims 14-16] claim 14 and wherein said trigger comprises a laser which produces a beam of laser radiation and directs said beam onto the odorant site.

22. (Amended) The system according to [any of claims 14-16] claim 14 and wherein said odorant sites are mounted on a substrate, and said odorant output device further comprises a motion device connected to said substrate which moves said substrate with respect to said trigger so as to selectively align one of said odorant sites with said trigger so that said trigger selectively applies said predetermined level of energy to said odorant sites.

23. (Amended) The system according to [any of claims 14-16] claim 14 and wherein said odorant sites are mounted on a substrate, and said odorant output device further comprises a motion device connected to said trigger which moves said trigger with respect to said substrate

so as to selectively align one of said odorant sites with said trigger so that said trigger selectively applies said predetermined level of energy to said odorant sites.

24. (Amended) The system according to [any of claims 14-16] claim 14 and comprising a controller connected to said trigger which controls to which of said odorant sites said trigger selectively applies said predetermined level of energy.

25. (Amended) The system according to [any of claims 14-16] claim 14 and comprising a fan which creates a flow of air over said odorant sites.

35. (Amended) The odorant output device according to [any of claims 32-34] claim 32 and wherein said trigger applies at least one of heat energy, light energy and mechanical energy.

36. (Amended) The odorant output device according to [any of claims 32-34] claim 32 and wherein said trigger comprises a scratch implement.

37. (Amended) The odorant output device according to [any of claims 32-34] claim 32 and wherein said enclosure has a property of locally rupturing upon application of said predetermined level of energy.

38. (Amended) The odorant output device according to [any of claims 32-34] claim 32 and wherein said enclosure has a permeability which increases upon application of said predetermined level of energy.

39. (Amended) The odorant output device according to [any of claims 32-34] claim 32 and wherein said trigger comprises a laser which produces a beam of laser radiation and directs said beam on the enclosure.

40. (Amended) The odorant output device according to [any of claims 32-34] claim 32 and wherein said odor sites are mounted on a substrate, and said odorant output device further comprises a motion device connected to said substrate which moves said substrate with respect

to said trigger so as to selectively align one of said odor sites with said trigger so that said trigger selectively applies said predetermined level of energy to said odor sites.

41. (Amended) The odorant output device according to [any of claims 32-34] claim 32 and wherein said odor sites are mounted on a substrate, and said odorant output device further comprises a motion device connected to said trigger which moves said trigger with respect to said substrate so as to selectively align one of said odor sites with said trigger so that said trigger selectively applies said predetermined level of energy to said odor sites.

42. (Amended) The odorant output device according to [any of claims 32-34] claim 32 and comprising a controller connected to said trigger which controls to which of said odor sites said trigger selectively applies said predetermined level of energy.

43. (Amended) The odorant output device according to [any of claims 32-34] claim 32 and comprising a fan which creates a flow of air over said odor sites.

METHODS AND APPARATUS FOR ODOR REPRODUCTION

FIELD OF THE INVENTION

The present invention relates generally to apparatus and methods for generation, emission, transmission, reproduction and memory storage of fragrances, scents, odors and smells.

BACKGROUND OF THE INVENTION

Apparatus and methods for sensing odors are well known in the art. For example, sensing, identifying or categorizing a particular odor may be accomplished by means of gas chromatography devices and mass spectrometers which chemically analyze an odor, and electronic or artificial "noses" which provide a characterizing fingerprint of the odor.

Presently there does not exist a precise method for reading and interpreting the human nose receptors signals that are sent to the brain. It is also not possible to fully understand the brain's smell-related activity. Therefore, it is still not possible to correlate each odorant, presented to a human nose, with its corresponding sensory neuronal activity. An alternative method for deciphering the human smell sensation is by receiving sensory feedback from a trained panel of human subjects. This panel of subjects provides for each odorant a fingerprint, which may be viewed as an alternative to the one that would have been produced by neuronal recordings. This is done by providing the panel with a list of quality descriptors, and asking each person to provide a numerical assessment of the similarity or dissimilarity of a test odorant relative a specific group of odorants with known quality descriptors. By averaging across the entire human panel, an odorant becomes represented by an odorant vector.

Odorant output devices for delivery of fragrances to a user's nose are also well known. For example, a fragrance output device used in conjunction with virtual reality systems is described in US Patent 5,591,409 to Watkins. US Patent 5,724,256 to Lee et al. describes a fragrance mixing device which can be used in multimedia systems.

Systems which attempt to link odor sensing devices with odor delivery devices are known in the prior art. For example, "Transmission of Olfactory Information for Telemedicine", Keller *et al.*, Interactive Technology and the New Paradigm for Healthcare, K. Morgan *et al.*, eds., IOS Press and Ohmsha, Amsterdam, 1995, chapter 27, pp. 168-172, contemplates sensing known, predetermined odors with sensing devices, transmitting odor information related to the known odors to an odorant output device, and using the output device to replicate the known input odor. It is important to note that this reference and the above cited fragrance mixing devices of the art strive to attain an *exact* reproduction of a *predetermined* input odor.

Over the years there have been many attempts to find explanations for odor sensation. Most of the theories used an analogy to color vision and assumed there are primary odors in smell just as there are primary colors (Red/Green/Blue or RGB) in vision. Beginning with the pioneering work of John Amoore in the 60's, researchers have investigated the physical and chemical attributes of odorant molecules to try to find a correlation between such attributes and odorant quality perception (Amoore JE, Specific anosmia: a clue to the olfactory code, Nature. 1967, 214(93):1095-8).

However, more than 30 years later, there is still no accepted way to define primary odors and to utilize a code to mix odorants at will, so as to recreate an arbitrary odor sensation. There have been whimsical and April-Fools-Day essays about an odor-version of RGB. For example, in May 1998 there appeared on the Internet a website with the domain name www.vol.it/sbdi/44/sbdi44it.htm, which described an odor system having 7 basic "RGB" odors - camphor, moss, flowers, mint, ether, putrid odor, and pungent odor. It is noted that this allegation is a pale imitation of the original Amoore proposed scheme of seven primary odors, which has been long since recognized in the art to be simplistic, and even erroneous. Another joke of note in the Internet is the website of RealAroma at www.realaroma.com that describes a machine with 3 basic "RGB" odors. However, notwithstanding such published farces, the prior art does not currently know of any primary odors which are analogous to primary colors.

In summary, it is clear that the prior art does not seriously address a fundamental problem of odor transmission: how to communicate and reproduce an arbitrary odor which is not predetermined or previously known.

SUMMARY OF THE INVENTION

The present invention seeks to provide methods for instructing an odorant-mixing output device to mix predetermined odorants in the correct amounts and proportions so as to translate any odor input, even an unknown odor, into an odorant output which faithfully reproduces the input odor.

It is noted that throughout the specification and claims the terms fragrances, aromas, flavors, scents, odors and smells, and any derivatives thereof, are used interchangeably. The term "odorant" denotes a substance which contributes to an emission of an odor by an odorant output device. The odorant does not necessarily give off an odor, but may catalyze emission of an odor. The odorant may be a pure substance or a mixture of substances.

A method of the present invention for reproducing odors relies on the mathematical interpretation of affinity fingerprints of odorants. Affinity of an odorant is the strength of interaction between the odorant molecule and the surface of a sensor or receptor. Hence, the total affinities of a specific odorant with a group of receptors or sensors is called the affinity fingerprint of the odorant or the odorant fingerprint. This odorant fingerprint can be represented by a vector called an odorant vector.

In a preferred embodiment of the present invention, an odorant concentration vector generator receives an odorant fingerprint represented by a vector of an arbitrary input odor r sensed by an odor sensor. The arbitrary input odor is not necessarily predetermined or previously known. The odorant concentration vector generator computes a concentration vector, which is employed to instruct an odorant output device how to mix odorants in suitable proportions to create a composite output odor which approximates the input odor. The odorant output device has an odorant palette containing a multiplicity of predetermined odorants, each having a predetermined odorant fingerprint represented as a vector. The predetermined odorants are preferably predefined by using the same method used to characterize the fingerprint of odor r, thereby creating a matrix of odorant vectors, which characterize the odorants of the palette. This matrix, multiplied by the concentration vector, creates an output odorant vector which characterizes an output odor r' which approximates the input odor r. The

output odor r' is thus a combination of different concentrations of odorants, the concentrations being defined by the concentration vector.

The output odor r' is not necessarily an exact duplication of the input odor r. Specifically, the difference in odor between input odor r and output odor r' as perceived by a sufficiently representative human population is called a tolerance δ. The present invention provides methods for minimizing tolerance δ such that the sufficiently representative human population perceives the output odor r' as an adequate substitute for input odor r.

The following is an illustrative example of the type of odor transmission possible with the present invention and not possible with the prior art. A movie director would like to add fragrances to scenes in a plurality of movies. In the prior art, the director must decide ahead of time which odors are to be transmitted. As mentioned in the background of the invention, the director must then provide all the end-users with the odorants needed to reproduce all of the known odors. If it is desired to transmit 1000 odors, then the director must either provide 1000 odorants which emit the same odors or somehow figure out how to mix the proper proportions of a smaller amount of basic odorants in order to reproduce the 1000 odors. In the prior art, the director has no way of knowing if 50, 600 or 999 predetermined odors are needed to reproduce the 1000 given odors and no way of knowing what the proper proportions are.

In contrast, the director can use the methods and teachings of the present invention to know if 1000 predetermined odorants are really needed or if 49 are sufficient, and to know what proportions of which odorants to mix to achieve the desired output odors, without time-consuming and laborious trial-and-error. Much more importantly, the director is not limited to known input odors. Rather, unknown odors, such as that provided by surprise or improvisation, can also be transmitted and faithfully mimicked using the methods of the present invention.

There is thus provided in accordance with a preferred embodiment of the present invention a system for producing an odorant concentration vector including an odorant fingerprint generator providing an odorant fingerprint representing an arbitrary odor, and an odorant concentration vector generator receiving the odorant fingerprint represented as a vector and producing an odorant concentration vector.

There is also provided in accordance with a preferred embodiment of the present invention a system for reproducing odors including an odor sensor providing a sensed odor input fingerprint representing an arbitrary odor sensed thereby, an odorant output device, having a palette containing a multiplicity of predetermined odorants each having a predetermined odorant fingerprint, the odorant output device providing a composite odor in response to an odorant concentration vector, and an odorant concentration vector generator receiving the sensed odorant fingerprint represented as a vector and utilizing the predetermined odorant fingerprints also represented as vectors to produce the odorant concentration vector.

In accordance with a preferred embodiment of the present invention the odor reproducing system also includes an odorant fingerprint normalizer which modifies the sensed odorant fingerprint such that the output of the sensor is normalized, whereby odors which are similar as perceived by a human are represented by modified sensed odorant fingerprints which are close in the vector sense.

Further in accordance with a preferred embodiment of the present invention the predetermined odorant fingerprints of the output device are also normalized in a similarity to the normalization of the sensed odorant fingerprint.

Closeness in the vector sense as the term is used above means that the distance in some metric space or generalized metric space is short. These spaces can be, for example, the Minkowsky metric, the Euclidean metric, the generalized Euclidean metric, the additive segment metric, etc. The distance can be for example the Euclidean distance, the generalized Euclidean distance, the Minkowsky distance, the over-threshold Euclidean distance, the over-threshold average difference, the maxima distance, etc.

Additionally in accordance with a preferred embodiment of the present invention the odorants of the palette are preferably predefined in terms of the sensed odorant vectors, wherein the palette includes q odorants which are defined by a matrix M of q odorant vectors $(\omega_{1,1}, \omega_{1,2}, \ldots \omega_{1,n})$, $(\omega_{2,1}, \omega_{2,2}, \ldots \omega_{2,n})$, ... $(\omega_{q,1}, \omega_{q,2}, \ldots \omega_{q,n})$.

In accordance with a preferred embodiment of the present invention the concentration vector generator generates a concentration vector b which instructs the palette how to mix the q odorants in order to create an output odor r' which mimics an

input odor r, wherein the matrix M multiplied by the concentration vector b creates an odorant vector $\omega' = (\omega'_1, \omega'_2, \ldots \omega'_n)$ and the concentration vector generator chooses the concentration vector b so as to minimize the distance $||M \cdot b - \omega|| = ||\omega' - \omega|| = \delta$.

Further in accordance with a preferred embodiment of the present invention δ is a distance which is minimized such that a sufficiently representative human population perceives the odor r' as an adequate substitute for the odor r.

Still further in accordance with a preferred embodiment of the present invention δ is a proper distance or generalized distance function, such as the Euclidean distance, the generalized Euclidean distance, the Minkowsky distance, the over-threshold Euclidean distance, the over-threshold average difference, the maxima distance, etc., defined in terms of metric space for example the Minkowsky metric, the Euclidean metric, the generalized Euclidean metric, the additive segment metric, etc..

Additionally in accordance with a preferred embodiment of the present invention the odorant fingerprint normalizer carries out a function f which operates on one kind of numerical vectors representing one kind of odorant fingerprints to form another kind of numerical vectors representing another kind of odorant fingerprints, not necessarily having the same dimensionality as the first kind of vectors, with the following property: if ω_1 and ω_2 are outputs of the odor sensor corresponding to odors r_1 and r_2, then the odor r_1 is perceived by a human nose as being close to odor r_2 if and only if $f(\omega_1)$ and $f(\omega_2)$ are numerically close.

In accordance with a preferred embodiment of the present invention the function f is constructed by comparing the sensed odor vectors ω from a variety of input odorants to other vectors produced by collecting data from a human panel for the same variety of input odors.

Further in accordance with a preferred embodiment of the present invention the function f is constructed by comparing the sensed odorant vectors ω from a variety of input odorants to other vectors produced by collecting data from actual human olfactory receptors for the same variety of input odors.

Still further in accordance with a preferred embodiment of the present invention the function f is constructed by comparing the sensed odorant vectors ω from a

variety of input odorants to other vectors produced by collecting data from a simulation of human olfactory receptors for the same variety of input odors

Still further in accordance with a preferred embodiment of the present invention, the function f is constructed by one of the following methods and similarly known ones from computational algebra: polynomial approximation, fuzzy logic, or neural networks. An example of a neural net implementation in this context is a feed forward net with a linear output layer and a sigmoid transfer function hidden layer, or layers. Such a construction is known to be able to approximate any continuous function of the desired type to any desired accuracy. Here the input is the set of fingerprints of an electronic nose, and the output is the set of fingerprints obtained by a human panel. Another possible neural network which may be used for this purpose is the radial basis net, which is also known to be able to approximate any continuous function.

Still further in accordance with a preferred embodiment of the present invention, construction of function f might involve computing in a reduced dimensionality using methods such as PCA (principle component analysis), MDS (multi-dimensional scaling) and neural networks.

Additionally in accordance with a preferred embodiment of the present invention there is provided an output device including an array of odorant sites, each odorant site including an odorant in an enclosure, the enclosure allowing passage of the odorant therethrough only upon application of a predetermined level of energy to the enclosure, and a trigger that selectively applies the predetermined level of energy to the enclosure. Preferably the trigger applies at least one of heat energy, light energy and mechanical energy.

In accordance with a preferred embodiment of the present invention the trigger includes a scratch implement.

Further in accordance with a preferred embodiment of the present invention the enclosure has a property of locally rupturing upon application of predetermined of energy.

Still further in accordance with a preferred embodiment of the present invention the enclosure has a permeability which increases upon application of the predetermined level of energy.

Additionally in accordance with a preferred embodiment of the present invention the trigger includes a laser which produces a beam of laser radiation and directs the beam onto the enclosure.

In accordance with a preferred embodiment of the present invention the odorant sites are mounted on a substrate, and the odorant output device further includes a motion device connected to the substrate which moves the substrate with respect to the trigger so as to selectively align one of the odorant sites with the trigger so that the trigger selectively applies the predetermined level of energy to the odorant sites.

Further in accordance with a preferred embodiment of the present invention the odorant- sites are mounted on a substrate, and the odorant output device further includes a motion device connected to the trigger which moves the trigger with respect to the substrate so as to selectively align one of the odorant sites with the trigger so that the trigger selectively applies the predetermined level of energy to the odorant sites.

Additionally in accordance with a preferred embodiment of the present invention there is provided an odorant output device that include a plurality of reservoirs each containing an odorant and a selectable odorant release trigger mechanism associated with said plurality of reservoirs for selectably releasing odorants therefrom.

The odorant release mechanism preferably comprises a drop on demand ink jet type mechanism which may be for example by thermal energy addition or may employ a piezoelectric crystal.

Still further in accordance with a preferred embodiment of the present invention there is provided a controller connected to the trigger which controls to where in the enclosure the trigger should selectively apply the predetermined level of energy.

Additionally in accordance with a preferred embodiment of the present invention a fan creates a flow of air over the odor sites.

There is also provided in accordance with a preferred embodiment of the present invention an odorant output device including an array of odorant sites, each the odorant site including an odor in an enclosure material, the enclosure material allowing passage of the odor therethrough only upon application of a predetermined level of

energy to the enclosure, and a trigger that selectively applies the predetermined level of energy to the odorant sites.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be understood and appreciated more fully from the following detailed description, taken in conjunction with the drawings in which:

Fig. 1 is a simplified block diagram of an odor transmission system, constructed and operative in accordance with a preferred embodiment of the present invention;

Fig. 2 is a simplified block diagram of an odor transmission system, constructed and operative in accordance with another preferred embodiment of the present invention, wherein odorant fingerprints are modified by an odorant fingerprint normalizer;

Fig. 3 is a simplified illustration of an odorant output device constructed and operative in accordance with a preferred embodiment of the present invention;

Fig. 4 is a simplified illustration of an alternative trigger for the odorant output devices of the present invention, constructed and operative in accordance with a preferred embodiment of the present invention;

Fig. 5 is a simplified illustration of an alternative odorant output device constructed and operative in accordance with preferred embodiment of the present invention; and

Fig. 6 is a simplified illustration of an alternative odorant output device constructed and operative in accordance with preferred embodiment of the present invention.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

Reference is now made to Fig. 1 which is a block diagram of an odor transmission system constructed and operative in accordance with a preferred embodiment of the present invention. It is desired to communicate a given input odor r. Odor r may be characterized in a number of ways. For example, gas chromatography can be used to represent odor r as a series of chemical constituents, c_1 , c_2 , .. c_n , such as 3

units of H_2S, 5 units of 3-methoxy-4-hydroxybenzaldehyde, and so forth. Alternatively, an artificial nose can be used to represent odor r as a function of "odor characteristics" s_1 , s_2 ,... s_n . Similarly, a panel of a representative population of humans can be used to represent odor r as a function of "odor characteristics" t_1 , t_2 ,... t_n . In short, odor r can be represented by an odorant fingerprint expressed as an odorant vector $\omega = (\omega_1, \omega_2, \ldots \omega_n)$.

It should be emphasized that it makes no difference what the source of odorant vector ω is. Odorant vector ω can be provided by sensing an object, such as a flower 12, whose odor is not necessarily previously known, as shown in Fig. 1. In the illustrated example, a sensor 20 such as an artificial nose may be provided. An example of an artificial nose is the Fox system by Alpha MOS at Toulouse, France, a description of which is available on the Internet at www.alpha-mos.com. Sensor 20 characterizes odor r by an odorant fingerprint represented as vector $\omega = (\omega_1 , \omega_2 , \ldots \omega_n)$. Alternatively, instead of creating an odorant vector ω by a sensor, it may be artificially created by a person, for example, by using an odorant-mixing device or a look-up table of a set of known odorant vectors or even by simply using one's imagination to dream up a new odorant vector.

An odorant output device 22 comprising an odorant palette 24 is preferably provided for generating an odor to an end-user via an odorant output port 26. An essential feature of one aspect of the present invention is instructing odorant output device 22 to reproduce odor r as faithfully as possible. This feature is described hereinbelow.

Odorant palette 24 comprises a plurality of q odorants. In order to use these q odorants as building blocks to reproduce odor r, the q odorants are preferably predefined in terms of the same type of ω vectors used to characterize odor r. In practical terms, this means that the odors given off by the q odorants of palette 24 are pre-sensed by sensor 20 prior to using palette 24 to produce odors. In mathematical terms, odorant palette 24 comprises q odors which are defined by a matrix M of q odorant vectors $(\omega_{1,1}, \omega_{1,2} \ldots \omega_{1,n})$, $(\omega_{2,1}, \omega_{2,2} \ldots \omega_{2,n})$, ... $(\omega_{q,1}, \omega_{q,2} \ldots \omega_{q,n})$.

In accordance with the present invention, a concentration vector generator 28 generates a concentration vector b which instructs odorant output device

22 how to mix the q odorants of palette 24 in order to create an output odor r' which mimics input odor r as closely as possible as perceived by a human nose. The matrix M is embodied in concentration vector generator 28 to make possible the following computation: In mathematical terms, matrix M multiplied by concentration vector b creates an odorant vector $\omega' = (\omega'_1, \omega'_2, \ldots \omega'_n)$. Concentration vector b is computed so as to minimize the distance $||M \cdot b - \omega|| = ||\omega' - \omega|| = \delta$. In other words, δ is a distance which is minimized such that a sufficiently representative human population perceives odor r' as an adequate representation of odor r.

The distance δ is defined in a metric space. In general, the metric used is the Euclidean one, i.e., $||\ ||_2$, in which case a suitable minimization technique is least squares, or calculus of variations. However, δ can also be defined in terms of other metrics, such as the maxima space, i.e., $||\ ||_\infty$, in which case techniques of linear programming can be used to minimize the distance δ. Other possible metrics include the over-threshold Euclidean distance, in which we take into account only those entries in the vectors that are over a certain threshold, over-threshold average difference, the Mahalanis distance from cluster analysis, the weighted Euclidean distance, the Minkowsky distance, the generalized Euclidean metric and the additive segment, etc. The present invention recognizes the possibility that minimizing the distance in Euclidean space may be inadequate to mimic odor r. Accordingly, other techniques, such as employing artificial neural networks, fuzzy logic, or genetic algorithms, are provided in the present invention for modifying the input vector ω so that a suitable minimization of δ will better reflect how a sufficiently representative human population perceives the output odor r'. This modification of input vector ω *is* described hereinbelow with reference to Fig. 2.

Several important features of embodiments of the present invention should be noted:

a. If the matrix M is non-singular or full-rank then $\delta = 0$ can be achieved, and a concentration vector b can be calculated to achieve $\delta = 0$, so that a mixture of the q odorants will always produce exactly the odorant vector of the input odorants. If matrix M is singular or non full-rank then in general $\delta \neq 0$, and a concentration vector

can be found that minimizes δ such that a sufficiently representative human population perceives odor r' as an adequate representation of odor r.

b. The present invention allows defining a set of q odorants that can produce a set of m odors within a desired tolerance δ. The present invention recognizes that for many practical applications, one does not need a set of odorants that work for every existing odor, but rather for a given set of odors. Nevertheless, it is theoretically possible to use the methods of the present invention to find a universal odorant palette that will be able to reproduce with sufficient accuracy any arbitrary odor.

c. The set of q primary odorants that can produce a set of m odors within a tolerance δ is not necessarily unique. Several sets of q odorants may adequately "do the job". The present invention also allows a user to find these sets and optimize and combine them at will.

d. The present invention allows the system to learn as it operates. In each representation of a new odor, the system examines the current odor palette and evaluates its effectiveness. It computes which odorants may be omitted and which new odorants could be added to the palette in order to construct a more accurate odor reproduction.

e. The present invention also recognizes that it is often desirable to have a palette containing some "main" odorants that will be present in larger quantities, with some secondary "condiment" odorants, in smaller quantities. This can be achieved by using odorant vectors normalized to the "human nose space" to generate clusters of similar odors. The main odors of the palette will then comprise a small number of odorants that best represent the principal components of the clustering procedure.

Reference is now made to Fig. 2 which illustrates an improved version of the system of Fig. 1. In accordance with a preferred embodiment of the present invention, a human nose normalizer 30 is provided which "normalizes" the odor fingerprint represented by vector ω produced by sensor 20. By "normalization" it is meant that the odorant vectors are modified so that the difference in vector representation between two odorant vectors accurately reflects the difference in human perception of the odors which these two odorant vectors represent.

In mathematical terms, human nose normalizer 30 uses a normalizing function f which operates on one kind of numerical vectors representing one kind of

odorant fingerprints to form numerical vectors of another kind representing another kind of odorant fingerprints, not necessarily having the same dimensionality as the first kind of vectors, with the following property: if ω_1 and ω_2 are outputs of sensor 20 corresponding to odors r_1 and r_2, then the odor r_1 is perceived by a human nose as being close to odor r_2 if and only if $f(\omega_1)$ and $f(\omega_2)$ are numerically close, e.g., in $||\ ||_2$.

The function f is also used to modify the odorant palette. As mentioned above, odorant palette 24 comprises q odors which are defined by a matrix M of q odorant vectors $(\omega_{1,1}, \omega_{1,2}, ...\omega_{1,n})$, $(\omega_{2,1}, \omega_{2,2}, ...\omega_{2,n})$, ... $(\omega_{q,1}, \omega_{q,2}, ...\omega_{q,n})$. The q odorant vectors are also operated on by function f, thereby producing a modified matrix, consisting of the vectors $f(\omega_{1,1}, \omega_{1,2}, ...\omega_{1,n})$, $f(\omega_{2,1}, \omega_{2,2}, ...\omega_{2,n})$, herein referred to as $f(M)$, which is embodied instead of matrix M, in concentration vector generator 28. The modified vector $f(\omega)$ of the input odor is then input into concentration vector generator 25, as seen in Fig. 2, to provide a better concentration vector b, that is, to minimize the distance $||f(M)\cdot b - f(\omega)||$.

A simple example may be constructed by providing an electronic nose that senses odors and represents them as odorant vectors ω in a 4-dimensional space. A "human nose space", represented, for example by a set of vectors π derived from a human panel, is 7-dimensional, i.e., the π-vectors are 7-dimensional. Suppose the palette is constructed of 6 odors, and is represented in the π-space as the following 7-by-6 matrix,

$$f(M)=\begin{pmatrix} 41 & 21 & 15 & 51 & 44 & 28 \\ 24 & 17 & 9 & 10 & 14 & 24 \\ 36 & 37 & 13 & 51 & 42 & 86 \\ 22 & 31 & 22 & 52 & 67 & 45 \\ 215 & 28 & 43 & 8 & 22 & 9 \\ 29 & 13 & 20 & 17 & 28 & 61 \\ 92 & 43 & 21 & 36 & 19 & 16 \end{pmatrix}.$$

Assuming that a new odor r is sensed by the electronic nose the following 4-vector is provided.

$$\omega = \begin{pmatrix} a \\ b \\ c \\ d \end{pmatrix} = \begin{pmatrix} 9 \\ 11 \\ 13 \\ 8 \end{pmatrix}.$$

If function f, that transforms from the ω-space to the π-space is

$$f = \begin{pmatrix} bc - ad - a^2 + d^2 \\ \frac{3}{4}(a+b) \\ (2a-b)^2 \\ 3a + 4b - 2c \\ b^2 - a^2 - c + d \\ b(b-a) \\ b(c-a) \end{pmatrix},$$

The odor r in π-space is

$$\pi = \begin{pmatrix} 54 \\ 15 \\ 49 \\ 45 \\ 35 \\ 22 \\ 44 \end{pmatrix}.$$

The concentration vector b can be found using an NNLS algorithm (non-negative least squares), which minimizes the quantity $\|f(M)\cdot b - \pi\|$ under the constraint that the elements of b are all non-negative. The resulting vector is

$$b = \begin{pmatrix} 0.1338 \\ 0 \\ 0 \\ 0.8603 \\ 0 \\ 0.0223 \end{pmatrix}.$$

Multiplying this vector by the palette matrix there is obtained

$$\pi' = f(M)\cdot b = \begin{pmatrix} 50 \\ 12 \\ 51 \\ 49 \\ 36 \\ 20 \\ 44 \end{pmatrix},$$

which is the closest possible non-negative vector to π.

One way of arriving at normalizing function f is by learning how the differences between ω vectors of sensor 20 actually reflect the differences between the same types of vectors in the "human nose space", for example by employing a set of vectors π derived from a human panel, as can be understood from the following example:, Suppose that a particular odorant vector ω_1 produced by sensor 20 is composed of the values (17, 5.3, 1.78), each scalar representing a quantity such as chemical concentration, or a dimensionless number related to an odor quantity. The same odor which produced this odorant vector ω_1 is then judged by a panel of a sufficiently representative human population which is asked to produce a vector of odor characteristics for that odor. This procedure produces a "human control" vector π_1 with, for example, the values (43.88, 60.84). This example also illustrates that these two vectors ω_1 and π_1 do not necessarily have the same length.

Suppose then that another odor is characterized by sensor 20 as the odorant vector ω_2 having the values (10.7, 5, 7.3), which when judged by the human control produces vector π_2 with, for example, the values (20, 54). Suppose further that a third odor is characterized by sensor 20 as the odorant vector ω_3 having the values (4.35, 4.99, 13.6), which when judged by the human control produces vector π_3 with, for example, the values (19.25, 54.06). Reflecting on these vectors, one notices the apparently illogical fact that while no two of the three ω vectors appear to be close (in the $||\ ||_2$ metric, for example), the two π vectors π_2 and π_3 are extremely close, while π_1 is distant from both of them. In this simple example, one might notice that this could have to do with the proximity of the second components of ω_2 and ω_3 (5 and 4.99) in

contrast with the relatively distant 5.3 of ω_1. The purpose of the sought-for function f is to discover these correlations. In this example, one possibility for a function f that fits the numbers is $f(x,y,z) = (y^3 - 105, 54y - 12(x + z))$, that takes the three components of the ω vectors, x, y, and z, and produces the two components of the π vectors. The dominance of y, the second component of the ω vectors, which may possibly represent some critical characteristic of the odors in question, now becomes very clear.

The above is a simple example which is presented to explain the basic principle of producing the concentration vector and finding and implementing the function f. In actuality, in the case of a human panel, many π odorant vectors would be polled by the panel and compared to the ω vectors to arrive at function f. For example, one can choose to represent function f as a polynomial with any number of terms, large or small, depending, *inter alia*, on the "number-crunching" ability of the processors used in the system, and then use best-fit techniques to arrive at the best-fit polynomial. It is of course appreciated by those skilled in the art of mathematics, that other well-known techniques can be used to construct function f, including techniques that handle the case when the dimension of the ω space is not equal to that of the π space, techniques that involve reduced dimensionalities

A second way of arriving at a normalizing function f is by learning how differences between ω vectors produced by sensor 20 are actually sensed by the odor receptors in the human olfactory nerve cells. Such an analysis of real human noses, potentially by remote sensing, including MRI or electromagnetic recordings, would then produce a set of θ vectors, constituting odorant fingerprints from the real nose. The θ vectors would be used, instead of vectors π of the human panel, to construct function f, which in turn would be used to create $f(\omega)$ and $f(M)$. $f(M)$ would then be included in concentration vector generator 28 and $f(\omega)$ would be input into concentration vector generator 28, as described above.

Alternatively, instead of analysis of real human noses to produce actual θ vectors, analysis could be performed on a set of simulated human noses, such as by chemical simulation of the θ vector space i.e., real-life odor receptors in the human olfactory nerve cells. Such an analysis would produce a set of θ_S vectors which could be used to construct function f as described above. Such simulations are based on the

receptor affinity distribution model (RAD), proposed by Lancet et. al.[Proc.Natl.Acad.Sci.USA Vol. 90, 3715:19,April 1993].

In summary, human nose normalizer 30 provides a normalizing function f that modifies the input vector ω and the odorant palette vectors to produce a better concentration vector. The function f can be learned and constructed by comparing the vectors ω from a variety of input odors to other vectors produced in the following ways:

a. Collecting data from a human panel for a variety of input odors.

b. Collecting data from actual human olfactory receptors.

c. Collecting data from chemical simulation of human olfactory receptors.

By improving the concentration vectors to improve the accuracy of odor reproduction, or by using a more accurate artificial nose, the relative quality of the q odorants is improved as well. The matrix M (or $f(M)$) associated with the q odorants spans some subspace of vectors of the input odors which are to be reproduced. If the matrix is non-singular or full-rank, then the mixture of the q odorants will always produce exactly the odorant vector of the input odors and the q odorants thus span all of the input odors.

If matrix M is singular or non full-rank then the q odorants do not span all of the input odors. Known mathematical techniques can be used to calculate to what extent the q odorants span the input odors in terms of a desired tolerance δ. Moreover, known mathematical techniques can be used to investigate the effects of adding new, additional odorants to the palette, and conversely, the effects of subtracting odorants from the palette. For example, one can calculate if adding certain odorants to the palette will create a non-singular or full-rank matrix and thus span all of the input odors. As another example, one can investigate the behavior of the palette upon the addition of odorants, such as 5 new odorants. If the 5 odorants greatly increase the span of the odorant palette, then they may be considered for expanded use of the palette. Conversely, if by subtracting 4 odorants from the palette no significant degradation in the ability of the palette to span the input odors is detected, then one can save costs by minimizing the number of odorants in the palette. In short, by using known mathematical techniques, matrix M and function f permit initially defining a set of q odorants that can produce a set of input odors within a tolerance δ, as well as modifying and optimizing

the set of q odorants. This palette analysis need not necessarily stop at some point. The system of the present invention can continue this analysis while working. Any new smell introduced to the sensor for reproduction may be analyzed as a potential palette odorant, and the system may analyze the power and efficiency of the proposed new palette. If the new proposed palette is better as a result of the addition of the new odor and/or the omission of other odors, the system may output its findings and the palette may be modified.

Another possible feature of the system may be the ability to translate vectors of one electronic nose to vectors of another electronic nose. Such a mathematical task can be carried out using function evaluation techniques, such as polynomial approximation, fuzzy logic or neural networks, with the input being the fingerprints of one electronic nose, and the output being the fingerprints of a different electronic nose.

Reference is now made to Fig. 3 which illustrates an odorant output device 110 constructed and operative in accordance with a preferred embodiment of the present invention, which employs the q odorants mentioned above.

Odorant output device 110 preferably includes an array of odorant sites 112 mounted on a substrate 114 which is preferably rigid. Each odorant site 112 includes an odorant 116 in an enclosure 118. Odorants 116 are preferably the q odorants and may be chosen in a number of ways. For example, it may be desired to use odorant output device 110 to approximate a plurality of input odors, such as perfumes, that include perfumes with known odors plus some with unknown odors. An initial plurality of odorants 116 that have a reasonable expectation of approximating at least the known odors may be selected. Then, as mentioned hereinabove, known mathematical techniques can be used to calculate to what extent the initially chosen odorants 116 span the input odors in terms of a desired tolerance δ. Moreover, known mathematical techniques can be used to investigate the effects of adding new, additional odorants to the palette, and conversely, the effects of subtracting odorants from the palette of odorant output device 110.

A trigger 120 which may be constructed in various ways as described further hereinbelow, is in operative communication with odorant sites 112. Enclosure

118 permits passage of odorant 116 into a surrounding environment when trigger 120 creates an opening in enclosure 118 sufficient for passage therethrough of odorant 116.

The type of trigger employed depends, *inter alia*, on the type of enclosure. Odorant 116 may be provided for example in a microcapsule (reservoir), a polymer matrix or a microencapsulated dispersed odor-polymer.

In Fig. 3, odorant sites 112 are preferably constructed of layers of a polymer matrix that may contain between 50-1000 different kinds of odorants. In order to describe the amount of odorant contained in the enclosure the following term, an "Odor signal", is employed. An "Odor signal" is defined as a portion of air carrying fragrance in a concentration sufficient for smell by humans. For many types of odorants, an ordinary person needs between 10 ngr - 10 μg of fragrance material in 1 liter of air in order to sense an "odor signal". Thus the amount required for thousands of potential breaths of fragrance may be contained in a small volume. Substrate 114 can be fashioned in any suitable shape, such as in the form of a compact disc.

In one preferred embodiment of the present invention, trigger 120 comprises a laser 122 which produces a beam 124 of laser radiation and directs it into enclosure 118. Enclosure 118 is preferably a light absorbing polymer with high absorptivity at the laser wavelength. The high absorptivity is preferably produced by an addition of a dye to the polymer which has a strong absorptivity at the laser wavelength. Alternatively a polymer that is intrinsically absorbing at the wavelength of the laser that may be employed. The laser beam 124 may be continuous or pulsed. The laser beam wavelength may be any suitably wavelength, but is most preferably between 680-1500 nm. The pulse intensity and duration of laser beam 124 preferably control the amount of odor 116 released from odor site 112. The laser apparatus can include optical fibers, lenses and other devices to focus and shape laser beam 124.

Laser beam 124 preferably can release odor 116 in one of three ways:

a. Evaporation of odor 116 that causes local explosion/rupture of the polymer wall of enclosure material 118.

b. Evaporation or destruction of the polymer wall of enclosure material 118 causing odor 116 to escape outwards.

c. Increase of the polymer wall permeability, causing faster diffusion of odor 116.

In accordance with one embodiment of the present invention, enclosure 118 can also be a heat-sensitive polymer, so that absorption of beam 124 heats the enclosure to a temperature which causes changes in the enclosure, in accordance with any of the three methods mentioned above. Examples of heat sensitive microcapsules are described in Japanese Patent Document 02145383 to Wakata and EP Patent 38985 to Bayer, in which a volatile material is released from a core of a capsule due to temperature changes in the enclosure. Another type of heat-sensitive microcapsule used in the food industry comprises microencapsulated flavors such as Ottens Flavors MagnaCap™ which are designed for release during baking at 145°F (63°C). Other examples of heat sensitive materials for such microcapsules are described in US Patent 4,742,043 to Tanaka et al. and US Patent 4,760,048 to Kurihara et al., the disclosures of which are incorporated herein by reference.

It is noted that enclosure 118 should preferably have a low thermal conductivity to prevent heat produced by laser beam 124 from traveling by conduction to other areas in the enclosure. This ensures the required localized heating of the particular odor site 112.

Substrate 114 may include layers of encapsulated odors apportioned into sections, each section including a different odorant. Odorant output device 110 preferably includes a motion device 130 connected to substrate 114 which moves substrate 114, together with odor sites 112, with respect to trigger 120 so as to selectively align one of odorant sites 112 with laser beam 124 of trigger 120. In this manner, 120 can selectively cause any combination of odorant sites 112 to release the particular odorant 116 therein.

In one embodiment, motion device 130 preferably includes a motor (not shown) which rotates substrate 114 about a spindle axis 132. Trigger 120 is preferably moved generally radially with respect to axis 132 by another motion device 134. Substrate 114 is rotated by motion device 130 until the desired fragrance location lies below laser beam 124. This system is thus similar to the system in a CD player or magnetic disk memory device.

Alternatively, trigger 120 may remain stationary while substrate 114 is moved by motion device 130 in Cartesian or other coordinates in a plane generally perpendicular to axis 132.

Preferably a fresh air supply conduit 136 is provided for introducing fresh, clean air above the substrate 114 and odor sites 112. An outlet conduit 138 is preferably positioned at a mixing region (or mixing chamber) 140 above the substrate 114 and odor sites 112 to deliver the air with the odors to a user's nose. The orientation of conduits 136 and 138 can be for example horizontal or vertical relative to substrate 114, and the conduits may even be concentric.

In summary, odorant output device 110 creates a composite odor from a combination of odors in different intensities. Trigger 120 and substrate 114 move relative to each other so as to release the precise amount of odor to the mixing region 140, just above substrate 114. The mixture of odors in the mixing region is delivered to the user's nose. After each fragrance emission, a flow of fresh air through conduits 136 and 138 cleans and clears apparatus 110.

Odorant output device 110 may also include a controller 142 connected to trigger 120 which determines which odorant sites 112 are triggered by trigger 120 to release odors 116.

Reference is now made to Fig. 4 which illustrates an alternative trigger for the odorant output devices of the present invention. Here the trigger comprises a scratch implement 180 which can scratch and rupture enclosure 118 of odor site 112, thereby releasing odorant 116. It is appreciated that the trigger of the odorant output devices of the present invention can use heat energy, light energy or mechanical energy to trigger emission of odors from odorant sites 112.

Reference is now made to Fig. 5 which illustrates an alternative odorant output device. This output device include a plurality of reservoirs 216 each containing an odorant 218 and a selectable odorant release trigger mechanism 220 associated with each of said plurality of reservoirs 216 for selectably releasing odorants 218 therefrom. The odorants release mechanism preferably comprises a conventional drop on demand ink jet type mechanism.

In one embodiment of the invention, illustrated in Fig. 6, a substrate 314 includes a CD ROM memory 316 on one side thereof and an odorant palette 318 on an opposite side thereof. A pair of lasers 320 and 322 are provided, laser 320 operating as a trigger for release of odorants and laser 322 operating to record on the CD ROM memory 316 that an odorant has been released from a given location on the palette 318. In this manner, efficient use of the various odorants on palette 318 may be provided.

It will be appreciated by persons skilled in the art that the present invention is not limited by what has been particularly shown and described hereinabove. Rather the scope of the present invention includes both combinations and subcombinations of the features described hereinabove as well as modifications and variations thereof which would occur to a person of skill in the art upon reading the foregoing description and which are not in the prior art.

CLAIMS

What is claimed is:

1. A system for producing an odorant concentration vector comprising:

an odorant fingerprint generator providing an odorant fingerprint representing an arbitrary odor; and

an odorant concentration vector generator receiving said odorant fingerprint and producing an odorant concentration vector.

2. A system for reproducing odors comprising:

an odor sensor providing a sensed odorant fingerprint representing an arbitrary odor sensed thereby;

an odorant output device, having a palette containing a multiplicity of predetermined odorants each having a predetermined odorant fingerprint, said odorant output device providing a composite odor in response to an odorant concentration vector; and

an odorant concentration vector generator receiving said sensed odorant fingerprint and utilizing said predetermined odorant fingerprints of said multiplicity of predetermined odorants in said palette to produce said odorant concentration vector.

3. The system for reproducing odors according to claim 2 and also comprising an odorant fingerprint normalizer which modifies the sensed odorant fingerprint such that the output of the sensor is normalized, whereby odors which are similar as perceived by a human are represented by modified sensed odorant fingerprints which are close in a vector sense.

4. The system for reproducing odors according to claim 3 and wherein said predetermined odorant fingerprints of said multiplicity of predetermined odorants in said palette are normalized by the said odorant fingerprint normalizer, whereby odors in the palette which are similar as perceived by a human are represented by modified odorant fingerprints which are close in a vector sense.

5. The system for reproducing odors according to claim 3 and wherein said modified odorant fingerprints which are close, are close in the vector sense according to at least one of the following metrics: Euclidean distance, the generalized Euclidean distance, the Minkowsky distance, the over-threshold Euclidean distance, the over-threshold average difference, the maxima distance.

6. The system for reproducing odors according to claim 2 and wherein said odorants of said palette are predefined in terms of a plurality of odorant fingerprints, wherein said palette comprises q odorants which are defined by a matrix M of q odorant vectors $(\omega_{1,1}, \omega_{1,2}, \ldots \omega_{1,n}), (\omega_{2,1}, \omega_{2,2}, \ldots \omega_{2,n}), \ldots (\omega_{q,1}, \omega_{q,2}, \ldots \omega_{q,n})$.

7. The system for reproducing odors according to claim 6 and wherein said concentration vector generator generates a concentration vector b which instructs said palette how to mix the q odorants in order to create an output odor r' which mimics an input odor r, wherein the matrix M multiplied by a concentration vector b creates an odorant vector $\omega' = (\omega'_1, \omega'_2, \ldots \omega'_n)$ and said concentration vector generator chooses a concentration vector b so as to minimize the distance $||M \cdot b - \omega|| = ||\omega' - \omega|| = \delta$.

8. The system for reproducing odors according to claim 7 and wherein δ is a distance which is minimized such that a sufficiently representative human population perceives the odor r' as an adequate substitute for the odor r.

9. The system for reproducing odors according to claim 8 and wherein δ is defined in terms of at least one of the following metrics: Euclidean distance, the generalized Euclidean distance, the Minkowsky distance, the over-threshold Euclidean distance, the over-threshold average difference, the maxima distance.

10. The system for reproducing odors according to claim 3 wherein said sensed odorant fingerprint normalizer carries out a function f which operates on one kind of numerical vectors representing one kind of odorant fingerprints to form another kind of numerical vectors representing another kind of odorant fingerprints, not necessarily

having the same dimensionality as the first kind of numerical vectors, with the following property: if ω_1 and ω_2 are outputs of said odor sensor corresponding to odors r_1 and r_2, then the odor r_1 is perceived by a human nose as being close to odor r_2 if and only if $f(\omega_1)$ and $f(\omega_2)$ are numerically close.

11. The system for reproducing odors according to claim 10 and wherein said function f is constructed by comparing the odorant vectors ω, corresponding to the odorant fingerprints from a variety of input odors to other odorant vectors representing collected data from a human panel for said variety of input odors.

12. The system for reproducing odors according to claim 10 and wherein said function f is constructed by comparing the odorant vectors ω, corresponding to the odorant fingerprints from a variety of input odors, to other vectors representing collected data from actual human olfactory receptors for said variety of input odors.

13. The system for reproducing odors according to claim 10 and wherein said function f is constructed by comparing the odorant input vectors ω, corresponding to the odorant fingerprints from a variety of input odors, to other vectors produced by collecting data from chemically simulation of human olfactory receptors for said variety of input odors.

14. The system according to claim 2 and wherein said odorant output device comprises:

an array of odorant sites, each said of odorant sites comprising an odorant, wherein release of an odor occurs upon application of a predetermined level of energy to said odor site; and

a trigger that selectively applies said predetermined level of energy to said odorant sites.

15. The system according to claim 14 and wherein said odorants are each encapsulated in an enclosure.

16. The system according to claim 14 and wherein said odorants are bound in a matrix.

17. The system according to any of claims 14-16 and wherein said trigger applies at least one of heat energy, light energy and mechanical energy.

18. The system according to any of claims 14-16 and wherein said trigger comprises a scratch implement.

19. The system according to any of claims 14-16 and wherein said odorant site has a property of locally rupturing upon application of said predetermined level of energy.

20. The system according to any of claims 14-16 and wherein said odorant site has a permeability which increases upon application of said predetermined level of energy.

21. The system according to any of claims 14-16 and wherein said trigger comprises a laser which produces a beam of laser radiation and directs said beam onto the odorant site.

22. The system according to any of claims 14-16 and wherein said odorant sites are mounted on a substrate, and said odorant output device further comprises a motion device connected to said substrate which moves said substrate with respect to said trigger so as to selectively align one of said odorant sites with said trigger so that said trigger selectively applies said predetermined level of energy to said odorant sites.

23. The system according to any of claims 14-16 and wherein said odorant sites are mounted on a substrate, and said odorant output device further comprises a motion device connected to said trigger which moves said trigger with respect to said

substrate so as to selectively align one of said odorant sites with said trigger so that said trigger selectively applies said predetermined level of energy to said odorant sites.

24. The system according to any of claims 14-16 and comprising a controller connected to said trigger which controls to which of said odorant sites said trigger selectively applies said predetermined level of energy.

25. The system according to any of claims 14-16 and comprising a fan which creates a flow of air over said odorant sites.

26. The system according to claim 2 and wherein said odorant output device comprises a plurality of reservoirs each containing an odorant, and a selectable odorant release mechanism associated with said plurality of reservoirs for selectably releasing odorants therefrom.

27. The system according to claim 26 and comprising a fan which creates a flow of air over said odor reservoirs.

28. The system according to claim 27 and wherein said selectable odorant release mechanism comprises a drop on demand ink jet type mechanism.

29. The system according to claim 2 and wherein said odorant output device comprising a substrate having first and second oppositely facing surfaces, a laser read/write memory being formed on a first surface thereof and an odorant palette being formed on a second surface thereof.

30. The system according to claim 29 and also comprising first and second laser assemblies, said first laser assembly being operative to interact with said memory and said second laser assembly being operative to interact with said odorant palette.

31. The system according to claim 30 and wherein said first laser assembly is operative to record on said memory the location on said palette at which an odorant is released by said second laser assembly.

32. An odorant output device comprising:

an array of odorant sites, each of said odorant sites comprising an odorant, wherein release of an odor occurs upon application of a predetermined level of energy to said odorant site; and

a trigger that selectively applies said predetermined level of energy to said odorant sites.

33. The system according to claim 32 and wherein said odorants are each in an enclosure.

34. The system according to claim 32 and wherein said odorants are bound in a matrix.

35. The odorant output device according to any of claims 32-34 and wherein said trigger applies at least one of heat energy, light energy and mechanical energy.

36. The odorant output device according to any of claims 32-34 and wherein said trigger comprises a scratch implement.

37. The odorant output device according to any of claims 32-34 and wherein said enclosure has a property of locally rupturing upon application of said predetermined level of energy.

38. The odorant output device according to any of claims 32-34 and wherein said enclosure has a permeability which increases upon application of said predetermined level of energy.

39. The odorant output device according to any of claims 32-34 and wherein said trigger comprises a laser which produces a beam of laser radiation and directs said beam on the enclosure.

40. The odorant output device according to any of claims 32-34 and wherein said odor sites are mounted on a substrate, and said odorant output device further comprises a motion device connected to said substrate which moves said substrate with respect to said trigger so as to selectively align one of said odor sites with said trigger so that said trigger selectively applies said predetermined level of energy to said odor sites.

41. The odorant output device according to any of claims 32-34 and wherein said odor sites are mounted on a substrate, and said odorant output device further comprises a motion device connected to said trigger which moves said trigger with respect to said substrate so as to selectively align one of said odor sites with said trigger so that said trigger selectively applies said predetermined level of energy to said odor sites.

42. The odorant output device according to any of claims 32-34 and comprising a controller connected to said trigger which controls to which of said odor sites said trigger selectively applies said predetermined level of energy.

43 The odorant output device according to any of claims 32-34 and comprising a fan which creates a flow of air over said odor sites.

44. An odorant output device comprising:

a plurality of reservoirs each containing an odorant and a selectable odorant release mechanism associated with said plurality of reservoirs for selectably releasing odorants therefrom.

45. The system according to claim 44 and comprising a fan which creates a flow of air over said odor reservoirs.

46 The system according to claim 45 and wherein said selectable odorant release mechanism comprises a drop on demand ink jet type mechanism.

47. An odorant output device comprising a substrate having first and second oppositely facing surfaces, a laser read/write memory being formed on a first surface thereof and an odorant palette being formed on a second surface thereof.

48. The system according to claim 47 and also comprising first and second laser assemblies, said first laser assembly being operative to interact with said memory and said second laser assembly being operative to interact with said odorant palette.

49. The system according to claim 48 and wherein said first laser assembly is operative to record on said memory the location on said palette at which an odorant is released by said second laser assembly.

50. A method for reproducing odors comprising:

providing an odorant fingerprint representing an arbitrary odor;

providing an odorant output device, having a palette containing a multiplicity of predetermined odorants each having a predetermined odorant fingerprint, said odorant output device providing a composite odor in response to an odorant concentration vector; and

inputting said odorant fingerprint into an odorant concentration vector generator which utilizes said predetermined odorant fingerprints to produce said odorant concentration vector.

51. The method according to claim 50 and comprising predefining said odorants of said palette in terms of a plurality of odorant fingerprints, wherein said palette comprises q odorants which are defined by a matrix M of q odorant vectors $(\omega_{1,1}, \omega_{1,2}, \ldots \omega_{1,n}), (\omega_{2,1}, \omega_{2,2}, \ldots \omega_{2,n}), \ldots (\omega_{q,1}, \omega_{q,2}, \ldots \omega_{q,n})$.

52. The method according to claim 51 and comprising generating a concentration vector b which instructs said palette how to mix the q odorants in order to create an output odor r' which mimics an input odor r, wherein the matrix M multiplied by the concentration vector b creates an odorant vector $\omega' = (\omega'_1, \omega'_2, \ldots \omega'_n)$ and the concentration vector b is chosen so as to minimize the distance $||M \cdot b - \omega|| = ||\omega' - \omega|| = \delta$.

53. The method according to claim 52 and comprising calculating to what extent the q odorants span the input odors in terms of δ.

54. The method according to claim 53 and comprising investigating effects of adding new, additional odorants to the palette by investigating changes caused thereby in minimization of δ.

55. The method according to claim 53 and comprising investigating effects of subtracting odorants from the palette by investigating changes caused thereby in minimization of δ.

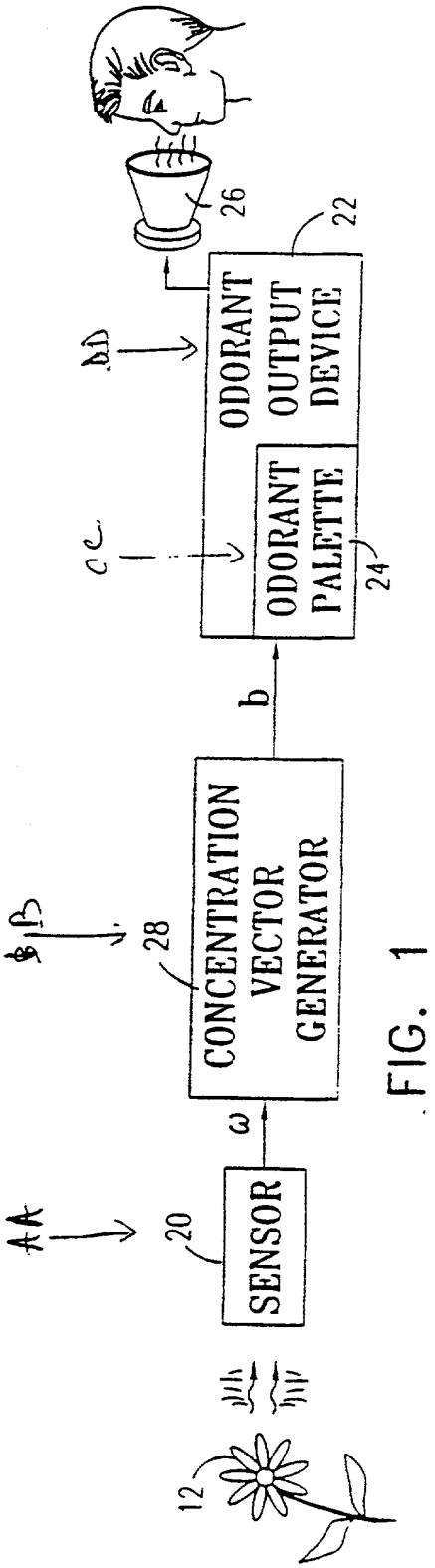

AA
20
SENSOR
ω
28
CONCENTRATION VECTOR GENERATOR
BB
b
ODORANT PALETTE
24
ODORANT OUTPUT DEVICE
22
CC
DD
26
12

FIG. 1

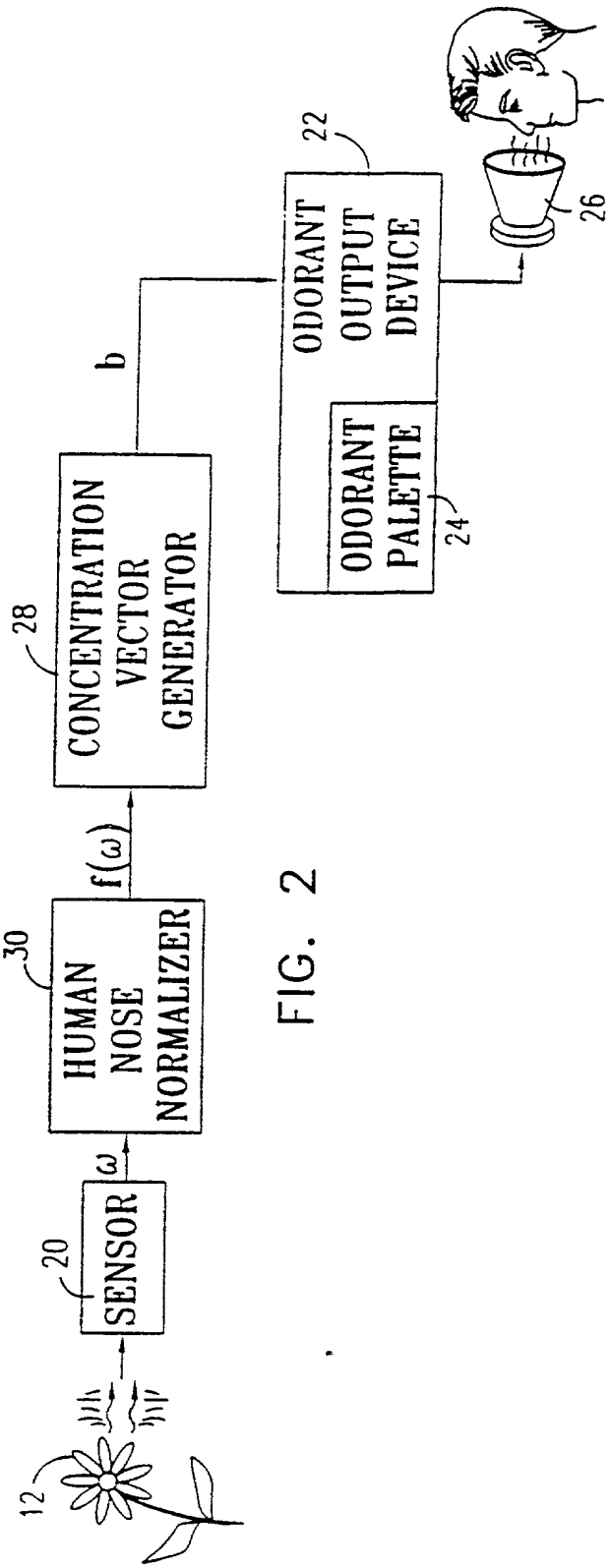

20
SENSOR
ω
30
HUMAN NOSE NORMALIZER
f(ω)
28
CONCENTRATION VECTOR GENERATOR
b
ODORANT PALETTE
24
ODORANT OUTPUT DEVICE
22
26
12

FIG. 2

FIG. 3

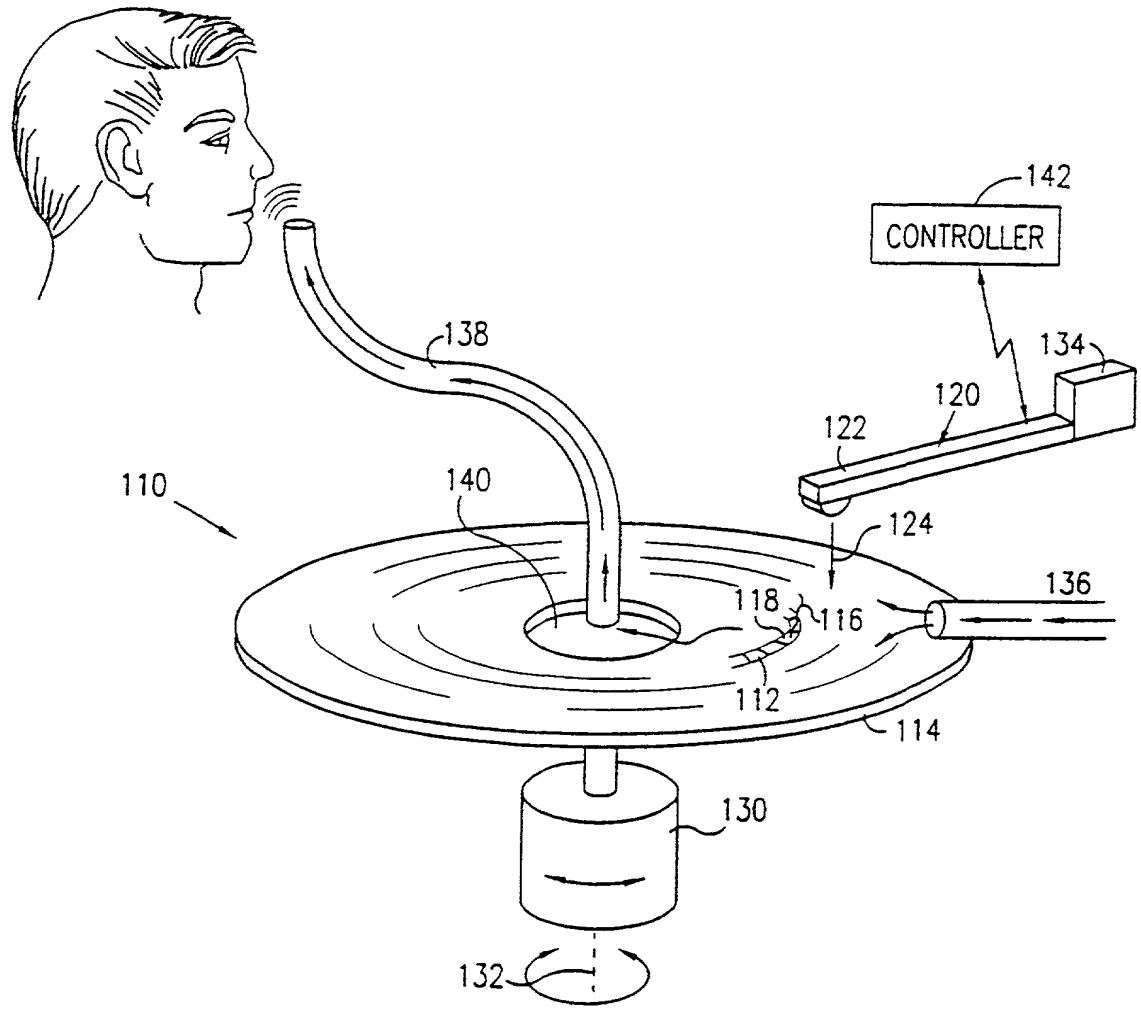
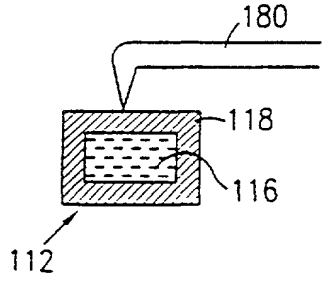

142
CONTROLLER
138
134
120
122
110
140
124
136
118
116
112
114
130
132

FIG. 4


180
118
116
112

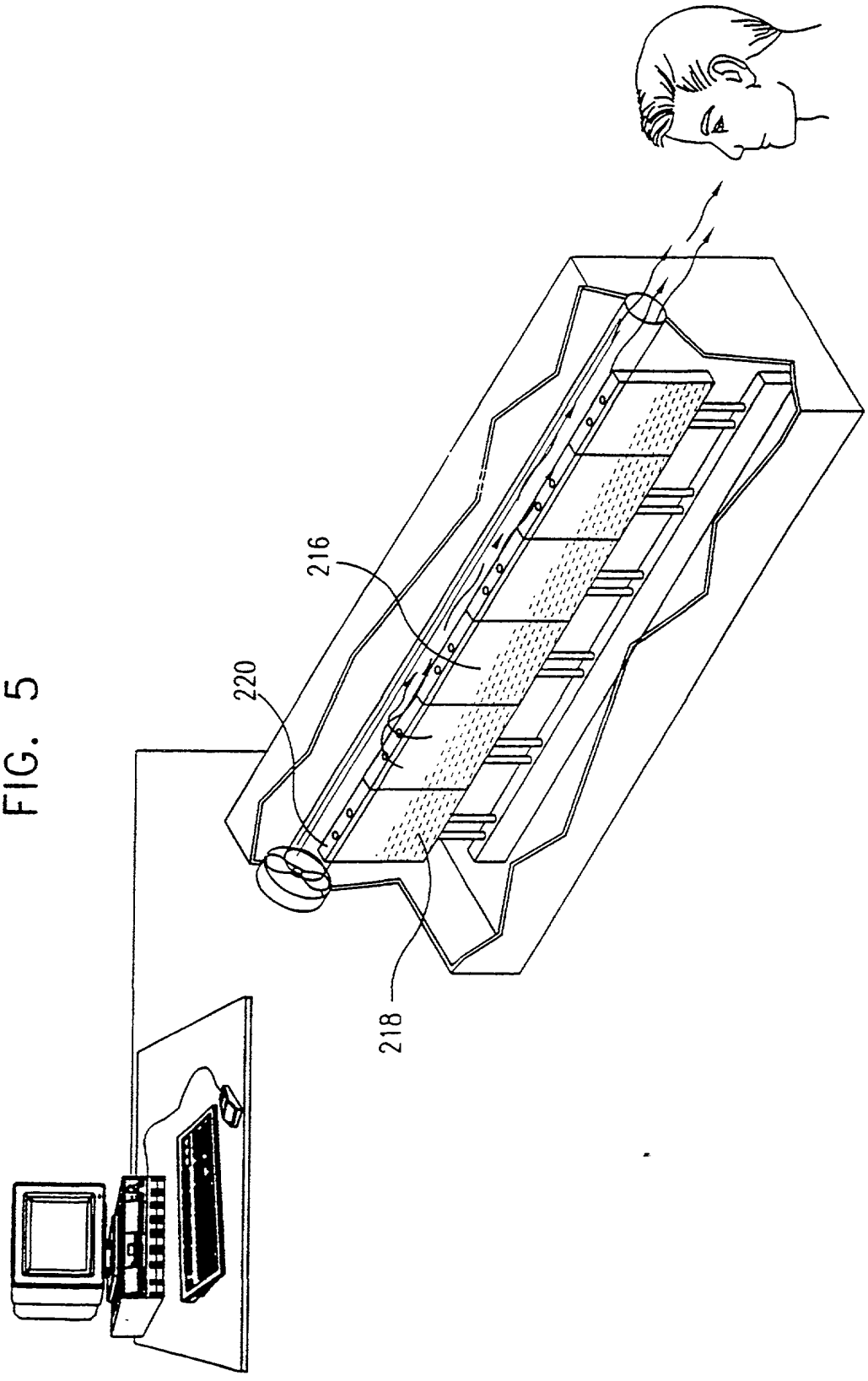
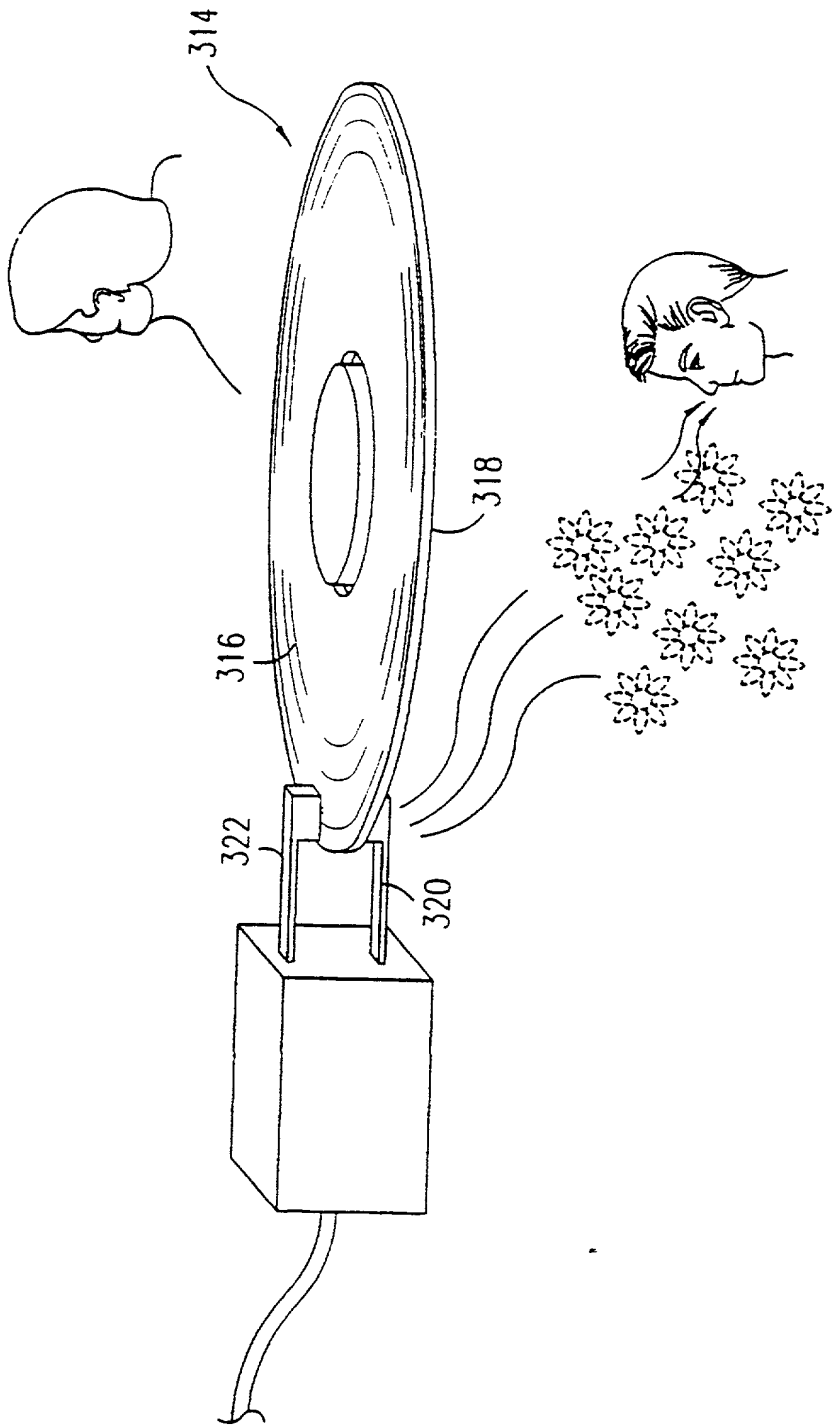


FIG. 5

FIG. 6



PATENT
Docket No. 422852000800

COMBINED DECLARATION FOR PATENT APPLICATION AND POWER OF ATTORNEY (Includes Reference to PCT International Applications)	ATTORNEY'S DOCKET NUMBER 422852000800

As a below named inventor I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name,

I believe I am the original, first and joint inventor of the subject matter which is claimed and for which a patent is sought on the invention entitled:

METHODS AND APPARATUS FOR ODOR REPRODUCTION

the specification of which (check only one item below):

☐ is attached hereto.

☐ was filed as United States application

Serial No. _____
on _____
and was amended on _____.

☒ was filed as PCT international application

Number PCT/IL99/00495
on 09/09/1999.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37 Code of Federal Regulations § 1.56(a) and (b).

I hereby claim foreign priority benefits under Title 35 United States Code § 119 of any foreign application(s) for patent or inventor's certificate or of any PCT international application(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed:

PRIOR FOREIGN/PCT APPLICATION(S) AND ANY PRIORITY CLAIMS UNDER 35 U.S.C. § 119:

COUNTRY (if PCT indicate "PCT")	APPLICATION NUMBER	DATE OF FILING (day, month, year)	PRIORITY CLAIMED UNDER 35 U.S.C. § 119
Israel	126168	10 September 1998	☒ YES ☐ NO
			☐ YES ☐ NO
			☐ YES ☐ NO
			☐ YES ☐ NO
			☐ YES ☐ NO

Combined Declaration for Patent Application and Power of Attorney (Continued) (Includes Reference to PCT International Applications)	ATTORNEY'S DOCKET NUMBER 422852000800

I hereby claim the benefit under Title 35, United States Code, § 120 of any United States application(s) or PCT international application(s) designating the United States of America that is/are listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in that/those prior application(s) in the manner provided by the first paragraph of Title 35, United States Code, § 112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, § 1.56(a) which occurred between the filing date of the prior application(s) and the national or PCT international filing date of this application:

PRIOR U.S. APPLICATIONS OR PCT INTERNATIONAL APPLICATIONS DESIGNATING THE U.S. FOR BENEFIT UNDER 35 U.S.C. § 120:

U.S. APPLICATIONS		STATUS *(Check one)*		
U S APPLICATION NUMBER	U S FILING DATE	PATENTED	PENDING	ABANDONED

PCT APPLICATIONS DESIGNATING THE U.S.			STATUS *(Check one)*		
PCT APPLICATION NUMBER	PCT FILING DATE	U S SERIAL NUMBERS ASSIGNED *(if any)*	PATENTED	PENDING	ABANDONED
PCT/IL99/00495	09/09/1999				√

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. ***(List name and registration number)***

Laurie A. Axford (Reg No. 35,053), Sanjay S. Bagade (Reg No. 42,280), Joseph Barrera (Reg No. 44,522), Erwin J. Basinski (Reg No. 34,773), Shantanu Basu (Reg No. 43,318), Richard R. Batt (Reg No. 43,485), Frank P. Becking (Reg No. 42,309), Vincent J. Belusko (Reg No. 30,820), Jonathan Bockman (Reg No. 45,640), Kimberly A. Bolin (Reg No. 44,546), Barry E. Bretschneider (Reg No. 28,055), Tyler S. Brown (Reg No. 36,465), Nicholas Buffinger (Reg No. 39,124), A. Randall Camacho (Reg No. 46,595), Mark R. Carter (Reg No. 39,131), Robert K. Cerpa (Reg No. 39,933), Peng Chen (Reg No. 43,543), Alex Chartove (Reg No. 31,942), Thomas Chuang (Reg No. 44,616), Thomas E. Ciotti (Reg No. 21,013), Cara M. Coburn (Reg No. 46,631), Matthew M. D'Amore (Reg No. 42,457), Raj S. Davé (Reg No. 42,465), Peter Davis (Reg No. 36,119), Stephen C. Durant (Reg No. 31,506), Carolyn A. Favorito (Reg No. 39,183), David L. Fehrman (Reg No. 28,600), Hector Gallegos (Reg No. 40,614), Thomas George (Reg No. 45,740), Debra J. Glaister (Reg No. 33,888), Kenneth R. Glick (Reg No. 28,612), Johney U. Han (Reg No. 45,565), Douglas G. Hodder (Reg No. 41,840), Alan S. Hodes (Reg No. 38,185), Charles D. Holland (Reg No. 35,196), Peter Hsieh (Reg No. 44,780), Wayne Jaeschke, Jr. (Reg No. 38,503), Madeline I. Johnston (Reg No. 36,174), Richard D. Jordan (Reg No. 33,519), Parisa Jorjani (Reg No. 46,813), Ararat Kapouytian (Reg No. 40,044), Richard C. Kim (Reg No. 40,046), Cameron A. King (Reg No. 41,897), Kawai Lau (Reg No. 44,461), Rimas T. Lukas (Reg No. 46,451), Michael J. Mauriel (Reg No. 44,226), Gladys H. Monroy (Reg No. 32,430), Philip A. Morin (Reg No. P-45,926), Kate H. Murashige (Reg No. 29,959), Martin M. Noonen (Reg No. 44,264), Catherine M. Polizzi (Reg No. 40,130), Paul J. Riley (Reg No. 38,596), Debra A. Shetka (Reg No. 33,309), Terri Shieh-Newton (Reg No. 47,081), Rebecca Shortle (Reg No. 47,083), Kevin R. Spivak (Reg No. 43,148), Stanley H. Thompson (Reg No. 45,160), Michael R. Ward (Reg No. 38,651), E. Thomas Wheelock (Reg No. 28,825), Todd W. Wight (Reg No. 45,218), Frank Wu (Reg No. 41,386), David T. Yang (Reg No. 44,415), Peter J. Yim (Reg No. 44,417), George C. Yu (Reg No. 44,418), Karen R. Zachow (Reg No. 46,332)

Send correspondence to:	Robert K. Cerpa Morrison & Foerster LLP 755 Page Mill Road Palo Alto, California 94304-1018	**Direct telephone calls to:** Robert K. Cerpa at (213) 892-5615

201	FULL NAME OF INVENTOR	FAMILY NAME FISCH	FIRST GIVEN NAME Eliezer	SECOND GIVEN NAME	
	RESIDENCE & CITIZENSHIP	CITY Raanana	STATE OR FOREIGN COUNTRY Israel	COUNTRY OF CITIZENSHIP Israel	
	POST OFFICE ADDRESS	POST OFFICE ADDRESS No. 15 Moshe Sne Street	CITY Raanana	STATE & ZIP CODE/COUNTRY Israel 43728	
202	FULL NAME OF INVENTOR	FAMILY NAME FINK	FIRST GIVEN NAME Sagit	SECOND GIVEN NAME	
	RESIDENCE & CITIZENSHIP	CITY Shoham	STATE OR FOREIGN COUNTRY Israel	COUNTRY OF CITIZENSHIP Israel	
	POST OFFICE ADDRESS	POST OFFICE ADDRESS P. O. Box 4043	CITY Shoham	STATE & ZIP CODE/COUNTRY Israel 73142	
203	FULL NAME OF INVENTOR	FAMILY NAME HAREL	FIRST GIVEN NAME David	SECOND GIVEN NAME	
	RESIDENCE & CITIZENSHIP	CITY Rehovot	STATE OR FOREIGN COUNTRY Israel	COUNTRY OF CITIZENSHIP Israel	
	POST OFFICE ADDRESS	POST OFFICE ADDRESS The Weizmann Institute of Science	CITY Rehovot	STATE & ZIP CODE/COUNTRY Israel 76100	

204	FULL NAME OF INVENTOR	FAMILY NAME LANCET	FIRST GIVEN NAME Doron	SECOND GIVEN NAME
	RESIDENCE & CITIZENSHIP	CITY Rehovot	STATE OR FOREIGN COUNTRY Israel	COUNTRY OF CITIZENSHIP Israel
	POST OFFICE ADDRESS	POST OFFICE ADDRESS 15 Weizmann Street	CITY Rehovot	STATE & ZIP CODE/COUNTRY Israel 76280

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

SIGNATURE OF INVENTOR 201 G. Figu	SIGNATURE OF INVENTOR 202	SIGNATURE OF INVENTOR 203
DATE 11.6.2021	DATE	DATE
SIGNATURE OF INVENTOR 204		
DATE		

COMBINED DECLARATION FOR PATENT APPLICATION AND POWER OF ATTORNEY (Includes Reference to PCT International Applications)	ATTORNEY'S DOCKET NUMBER 422852000800

As a below named inventor I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name,

I believe I am the original, first and joint inventor of the subject matter which is claimed and for which a patent is sought on the invention entitled:

METHODS AND APPARATUS FOR ODOR REPRODUCTION

the specification of which (check only one item below):

☐ is attached hereto.

☐ was filed as United States application

Serial No. _____
on _____
and was amended on _____.

☒ was filed as PCT international application

Number PCT/IL99/00495
on 09/09/1999.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37 Code of Federal Regulations § 1.56(a) and (b).

I hereby claim foreign priority benefits under Title 35 United States Code § 119 of any foreign application(s) for patent or inventor's certificate or of any PCT international application(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed:

PRIOR FOREIGN/PCT APPLICATION(S) AND ANY PRIORITY CLAIMS UNDER 35 U.S.C. § 119:

COUNTRY (if PCT indicate "PCT")	APPLICATION NUMBER	DATE OF FILING (day, month, year)	PRIORITY CLAIMED UNDER 35 U.S.C. § 119
Israel	126168	10 September 1998	☒ YES ☐ NO
			☐ YES ☐ NO
			☐ YES ☐ NO
			☐ YES ☐ NO
			☐ YES ☐ NO

Combined Declaration for Patent Application and Power of Attorney (Continued) (Includes Reference to PCT International Applications)	ATTORNEY'S DOCKET NUMBER 422852000800

I hereby claim the benefit under Title 35, United States Code, § 120 of any United States application(s) or PCT international application(s) designating the United States of America that is/are listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in that/those prior application(s) in the manner provided by the first paragraph of Title 35, United States Code, § 112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, § 1.56(a) which occurred between the filing date of the prior application(s) and the national or PCT international filing date of this application:

PRIOR U.S. APPLICATIONS OR PCT INTERNATIONAL APPLICATIONS DESIGNATING THE U.S. FOR BENEFIT UNDER 35 U.S.C. § 120:

U.S. APPLICATIONS		STATUS *(Check one)*		
U S APPLICATION NUMBER	U S FILING DATE	PATENTED	PENDING	ABANDONED

PCT APPLICATIONS DESIGNATING THE U.S.			STATUS *(Check one)*		
PCT APPLICATION NUMBER	PCT FILING DATE	U S SERIAL NUMBERS ASSIGNED *(if any)*	PATENTED	PENDING	ABANDONED
PCT/IL99/00495	09/09/1999				√

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. ***(List name and registration number)***

Laurie A. Axford (Reg No. 35,053), Sanjay S. Bagade (Reg No. 42,280), Joseph Barrera (Reg No. 44,522), Erwin J. Basinski (Reg No. 34,773), Shantanu Basu (Reg No. 43,318), Richard R. Batt (Reg No. 43,485), Frank P. Becking (Reg No. 42,309), Vincent J. Belusko (Reg No. 30,820), Jonathan Bockman (Reg No. 45,640), Kimberly A. Bolin (Reg No. 44,546), Barry E. Bretschneider (Reg No. 28,055), Tyler S. Brown (Reg No. 36,465), Nicholas Buffinger (Reg No. 39,124), A. Randall Camacho (Reg No. 46,595), Mark R. Carter (Reg No. 39,131), Robert K. Cerpa (Reg No. 39,933), Peng Chen (Reg No. 43,543), Alex Chartove (Reg No. 31,942), Thomas Chuang (Reg No. 44,616), Thomas E. Ciotti (Reg No. 21,013), Cara M. Coburn (Reg No. 46,631), Matthew M. D'Amore (Reg No. 42,457), Raj S. Davé (Reg No. 42,465), Peter Davis (Reg No. 36,119), Stephen C. Durant (Reg No. 31,506), Carolyn A. Favorito (Reg No. 39,183), David L. Fehrman (Reg No. 28,600), Hector Gallegos (Reg No. 40,614), Thomas George (Reg No. 45,740), Debra J. Glaister (Reg No. 33,888), Kenneth R. Glick (Reg No. 28,612), Johney U. Han (Reg No. 45,565), Douglas G. Hodder (Reg No. 41,840), Alan S. Hodes (Reg No. 38,185), Charles D. Holland (Reg No. 35,196), Peter Hsieh (Reg No. 44,780), Wayne Jaeschke, Jr. (Reg No. 38,503), Madeline I. Johnston (Reg No. 36,174), Richard D. Jordan (Reg No. 33,519), Parisa Jorjani (Reg No. 46,813), Ararat Kapouytian (Reg No. 40,044), Richard C. Kim (Reg No. 40,046), Cameron A. King (Reg No. 41,897), Kawai Lau (Reg No. 44,461), Rimas T. Lukas (Reg No. 46,451), Michael J. Mauriel (Reg No. 44,226), Gladys H. Monroy (Reg No. 32,430), Philip A. Morin (Reg No. P-45,926), Kate H. Murashige (Reg No. 29,959), Martin M. Noonen (Reg No. 44,264), Catherine M. Polizzi (Reg No. 40,130), Paul J. Riley (Reg No. 38,596), Debra A. Shetka (Reg No. 33,309), Terri Shieh-Newton (Reg No. 47,081), Rebecca Shortle (Reg No. 47,083), Kevin R. Spivak (Reg No. 43,148), Stanley H. Thompson (Reg No. 45,160), Michael R. Ward (Reg No. 38,651), E. Thomas Wheelock (Reg No. 28,825), Todd W. Wight (Reg No. 45,218), Frank Wu (Reg No. 41,386), David T. Yang (Reg No. 44,415), Peter J. Yim (Reg No. 44,417), George C. Yu (Reg No. 44,418), Karen R. Zachow (Reg No. 46,332)

Send correspondence to: Robert K. Cerpa Morrison & Foerster LLP 755 Page Mill Road Palo Alto, California 94304-1018	**Direct telephone calls to:** Robert K. Cerpa at (213) 892-5615

201	FULL NAME OF INVENTOR	FAMILY NAME FISCH	FIRST GIVEN NAME Eliezer	SECOND GIVEN NAME
	RESIDENCE & CITIZENSHIP	CITY Raanana	STATE OR FOREIGN COUNTRY Israel	COUNTRY OF CITIZENSHIP Israel
	POST OFFICE ADDRESS	POST OFFICE ADDRESS No. 15 Moshe Sne Street	CITY Raanana	STATE & ZIP CODE/COUNTRY Israel 43728
202	FULL NAME OF INVENTOR	FAMILY NAME FINK	FIRST GIVEN NAME Sagit	SECOND GIVEN NAME
	RESIDENCE & CITIZENSHIP	CITY Shoham	STATE OR FOREIGN COUNTRY Israel	COUNTRY OF CITIZENSHIP Israel
	POST OFFICE ADDRESS	POST OFFICE ADDRESS P. O. Box 4043	CITY Shoham	STATE & ZIP CODE/COUNTRY Israel 73142
203	FULL NAME OF INVENTOR	FAMILY NAME HAREL	FIRST GIVEN NAME David	SECOND GIVEN NAME
	RESIDENCE & CITIZENSHIP	CITY Rehovot	STATE OR FOREIGN COUNTRY Israel	COUNTRY OF CITIZENSHIP Israel
	POST OFFICE ADDRESS	POST OFFICE ADDRESS The Weizmann Institute of Science	CITY Rehovot	STATE & ZIP CODE/COUNTRY Israel 76100

204	FULL NAME OF INVENTOR	FAMILY NAME LANCET	FIRST GIVEN NAME Doron	SECOND GIVEN NAME
	RESIDENCE & CITIZENSHIP	CITY Rehovot ILX	STATE OR FOREIGN COUNTRY Israel	COUNTRY OF CITIZENSHIP Israel
	POST OFFICE ADDRESS	POST OFFICE ADDRESS 15 Weizmann Street	CITY Rehovot	STATE & ZIP CODE/COUNTRY Israel 76280

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

SIGNATURE OF INVENTOR 201	SIGNATURE OF INVENTOR 202	SIGNATURE OF INVENTOR 203
DATE	DATE	DATE
SIGNATURE OF INVENTOR 204 Doron Lancet		
DATE 23/5/01		

PATENT
Docket No. 422852000800

COMBINED DECLARATION FOR PATENT APPLICATION AND POWER OF ATTORNEY (Includes Reference to PCT International Applications)	ATTORNEY'S DOCKET NUMBER 422852000800

As a below named inventor I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name,

I believe I am the original, first and joint inventor of the subject matter which is claimed and for which a patent is sought on the invention entitled:

METHODS AND APPARATUS FOR ODOR REPRODUCTION

the specification of which (check only one item below):

☐ is attached hereto.

☐ was filed as United States application

Serial No. _____
on _____
and was amended on _____.

☒ was filed as PCT international application

Number PCT/IL99/00495
on 09/09/1999.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37 Code of Federal Regulations § 1.56(a) and (b).

I hereby claim foreign priority benefits under Title 35 United States Code § 119 of any foreign application(s) for patent or inventor's certificate or of any PCT international application(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed:

PRIOR FOREIGN/PCT APPLICATION(S) AND ANY PRIORITY CLAIMS UNDER 35 U.S.C. § 119:

COUNTRY (if PCT indicate "PCT")	APPLICATION NUMBER	DATE OF FILING (day, month, year)	PRIORITY CLAIMED UNDER 35 U.S.C. § 119
Israel	126168	10 September 1998	☒ YES ☐ NO
			☐ YES ☐ NO
			☐ YES ☐ NO
			☐ YES ☐ NO
			☐ YES ☐ NO

Combined Declaration for Patent Application and Power of Attorney (Continued) (Includes Reference to PCT International Applications)	ATTORNEY'S DOCKET NUMBER 422852000800

I hereby claim the benefit under Title 35, United States Code, § 120 of any United States application(s) or PCT international application(s) designating the United States of America that is/are listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in that/those prior application(s) in the manner provided by the first paragraph of Title 35, United States Code, § 112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, § 1.56(a) which occurred between the filing date of the prior application(s) and the national or PCT international filing date of this application:

PRIOR U.S. APPLICATIONS OR PCT INTERNATIONAL APPLICATIONS DESIGNATING THE U.S. FOR BENEFIT UNDER 35 U.S.C. § 120:

U.S. APPLICATIONS		STATUS *(Check one)*		
U S APPLICATION NUMBER	U S FILING DATE	PATENTED	PENDING	ABANDONED

PCT APPLICATIONS DESIGNATING THE U.S.			STATUS *(Check one)*		
PCT APPLICATION NUMBER	PCT FILING DATE	U S SERIAL NUMBERS ASSIGNED *(if any)*	PATENTED	PENDING	ABANDONED
PCT/IL99/00495	09/09/1999				√

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. ***(List name and registration number)***

Laurie A. Axford (Reg No. 35,053), Sanjay S. Bagade (Reg No. 42,280), Joseph Barrera (Reg No. 44,522), Erwin J. Basinski (Reg No. 34,773), Shantanu Basu (Reg No. 43,318), Richard R. Batt (Reg No. 43,485), Frank P. Becking (Reg No. 42,309), Vincent J. Belusko (Reg No. 30,820), Jonathan Bockman (Reg No. 45,640), Kimberly A. Bolin (Reg No. 44,546), Barry E. Bretschneider (Reg No. 28,055), Tyler S. Brown (Reg No. 36,465), Nicholas Buffinger (Reg No. 39,124), A. Randall Camacho (Reg No. 46,595), Mark R. Carter (Reg No. 39,131), Robert K. Cerpa (Reg No. 39,933), Peng Chen (Reg No. 43,543), Alex Chartove (Reg No. 31,942), Thomas Chuang (Reg No. 44,616), Thomas E. Ciotti (Reg No. 21,013), Cara M. Coburn (Reg No. 46,631), Matthew M. D'Amore (Reg No. 42,457), Raj S. Davé (Reg No. 42,465), Peter Davis (Reg No. 36,119), Stephen C. Durant (Reg No. 31,506), Carolyn A. Favorito (Reg No. 39,183), David L. Fehrman (Reg No. 28,600), Hector Gallegos (Reg No. 40,614), Thomas George (Reg No. 45,740), Debra J. Glaister (Reg No. 33,888), Kenneth R. Glick (Reg No. 28,612), Johney U. Han (Reg No. 45,565), Douglas G. Hodder (Reg No. 41,840), Alan S. Hodes (Reg No. 38,185), Charles D. Holland (Reg No. 35,196), Peter Hsieh (Reg No. 44,780), Wayne Jaeschke, Jr. (Reg No. 38,503), Madeline I. Johnston (Reg No. 36,174), Richard D. Jordan (Reg No. 33,519), Parisa Jorjani (Reg No. 46,813), Ararat Kapouytian (Reg No. 40,044), Richard C. Kim (Reg No. 40,046), Cameron A. King (Reg No. 41,897), Kawai Lau (Reg No. 44,461), Rimas T. Lukas (Reg No. 46,451), Michael J. Mauriel (Reg No. 44,226), Gladys H. Monroy (Reg No. 32,430), Philip A. Morin (Reg No. P-45,926), Kate H. Murashige (Reg No. 29,959), Martin M. Noonen (Reg No. 44,264), Catherine M. Polizzi (Reg No. 40,130), Paul J. Riley (Reg No. 38,596), Debra A. Shetka (Reg No. 33,309), Terri Shieh-Newton (Reg No. 47,081), Rebecca Shortle (Reg No. 47,083), Kevin R. Spivak (Reg No. 43,148), Stanley H. Thompson (Reg No. 45,160), Michael R. Ward (Reg No. 38,651), E. Thomas Wheelock (Reg No. 28,825), Todd W. Wight (Reg No. 45,218), Frank Wu (Reg No. 41,386), David T. Yang (Reg No. 44,415), Peter J. Yim (Reg No. 44,417), George C. Yu (Reg No. 44,418), Karen R. Zachow (Reg No. 46,332)

Send correspondence to:	**Direct telephone calls to:**
Robert K. Cerpa Morrison & Foerster LLP 755 Page Mill Road Palo Alto, California 94304-1018	Robert K. Cerpa at (213) 892-5615

201	FULL NAME OF INVENTOR	FAMILY NAME FISCH	FIRST GIVEN NAME Eliezer	SECOND GIVEN NAME
	RESIDENCE & CITIZENSHIP	CITY Raanana	STATE OR FOREIGN COUNTRY Israel	COUNTRY OF CITIZENSHIP Israel
	POST OFFICE ADDRESS	POST OFFICE ADDRESS No. 15 Moshe Sne Street	CITY Raanana	STATE & ZIP CODE/COUNTRY Israel 43728
202	FULL NAME OF INVENTOR	FAMILY NAME FINK	FIRST GIVEN NAME Sagit	SECOND GIVEN NAME
	RESIDENCE & CITIZENSHIP	CITY Shoham	STATE OR FOREIGN COUNTRY Israel	COUNTRY OF CITIZENSHIP Israel
	POST OFFICE ADDRESS	POST OFFICE ADDRESS P. O. Box 4043	CITY Shoham	STATE & ZIP CODE/COUNTRY Israel 73142
203	FULL NAME OF INVENTOR	FAMILY NAME HAREL	FIRST GIVEN NAME David	SECOND GIVEN NAME
	RESIDENCE & CITIZENSHIP	CITY Rehovot	STATE OR FOREIGN COUNTRY Israel	COUNTRY OF CITIZENSHIP Israel
	POST OFFICE ADDRESS	POST OFFICE ADDRESS The Weizmann Institute of Science	CITY Rehovot	STATE & ZIP CODE/COUNTRY Israel 76100

204	FULL NAME OF INVENTOR	FAMILY NAME LANCET	FIRST GIVEN NAME Doron	SECOND GIVEN NAME
	RESIDENCE & CITIZENSHIP	CITY Rehovot	STATE OR FOREIGN COUNTRY Israel	COUNTRY OF CITIZENSHIP Israel
	POST OFFICE ADDRESS	POST OFFICE ADDRESS 15 Weizmann Street	CITY Rehovot	STATE & ZIP CODE/COUNTRY Israel 76280

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

SIGNATURE OF INVENTOR 201	SIGNATURE OF INVENTOR 202	SIGNATURE OF INVENTOR 203
DATE	DATE 8/1/01	DATE
SIGNATURE OF INVENTOR 204		
DATE		

COMBINED DECLARATION FOR PATENT APPLICATION AND POWER OF ATTORNEY (Includes Reference to PCT International Applications)	ATTORNEY'S DOCKET NUMBER 422852000800

As a below named inventor I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name,

I believe I am the original, first and joint inventor of the subject matter which is claimed and for which a patent is sought on the invention entitled:

METHODS AND APPARATUS FOR ODOR REPRODUCTION

the specification of which (check only one item below):

☐ is attached hereto.

☐ was filed as United States application

Serial No. _____
on _____
and was amended on _____.

☒ was filed as PCT international application

Number PCT/IL99/00495
on 09/09/1999.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37 Code of Federal Regulations § 1.56(a) and (b).

I hereby claim foreign priority benefits under Title 35 United States Code § 119 of any foreign application(s) for patent or inventor's certificate or of any PCT international application(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed:

PRIOR FOREIGN/PCT APPLICATION(S) AND ANY PRIORITY CLAIMS UNDER 35 U.S.C. § 119:

COUNTRY (if PCT indicate "PCT")	APPLICATION NUMBER	DATE OF FILING (day, month, year)	PRIORITY CLAIMED UNDER 35 U.S.C. § 119
Israel	126168	10 September 1998	☒ YES ☐ NO
			☐ YES ☐ NO
			☐ YES ☐ NO
			☐ YES ☐ NO
			☐ YES ☐ NO

Combined Declaration for Patent Application and Power of Attorney (Continued) (Includes Reference to PCT International Applications)	ATTORNEY'S DOCKET NUMBER 422852000800

I hereby claim the benefit under Title 35, United States Code, § 120 of any United States application(s) or PCT international application(s) designating the United States of America that is/are listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in that/those prior application(s) in the manner provided by the first paragraph of Title 35, United States Code, § 112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, § 1.56(a) which occurred between the filing date of the prior application(s) and the national or PCT international filing date of this application:

PRIOR U.S. APPLICATIONS OR PCT INTERNATIONAL APPLICATIONS DESIGNATING THE U.S. FOR BENEFIT UNDER 35 U.S.C. § 120:

U.S. APPLICATIONS		STATUS *(Check one)*		
U S APPLICATION NUMBER	U S FILING DATE	PATENTED	PENDING	ABANDONED

PCT APPLICATIONS DESIGNATING THE U.S.			STATUS *(Check one)*		
PCT APPLICATION NUMBER	PCT FILING DATE	U S SERIAL NUMBERS ASSIGNED *(if any)*	PATENTED	PENDING	ABANDONED
PCT/IL99/00495	09/09/1999				√

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. ***(List name and registration number)***

Laurie A. Axford (Reg No. 35,053), Sanjay S. Bagade (Reg No. 42,280), Joseph Barrera (Reg No. 44,522), Erwin J. Basinski (Reg No. 34,773), Shantanu Basu (Reg No. 43,318), Richard R. Batt (Reg No. 43,485), Frank P. Becking (Reg No. 42,309), Vincent J. Belusko (Reg No. 30,820), Jonathan Bockman (Reg No. 45,640), Kimberly A. Bolin (Reg No. 44,546), Barry E. Bretschneider (Reg No. 28,055), Tyler S. Brown (Reg No. 36,465), Nicholas Buffinger (Reg No. 39,124), A. Randall Camacho (Reg No. 46,595), Mark R. Carter (Reg No. 39,131), Robert K. Cerpa (Reg No. 39,933), Peng Chen (Reg No. 43,543), Alex Chartove (Reg No. 31,942), Thomas Chuang (Reg No. 44,616), Thomas E. Ciotti (Reg No. 21,013), Cara M. Coburn (Reg No. 46,631), Matthew M. D'Amore (Reg No. 42,457), Raj S. Davé (Reg No. 42,465), Peter Davis (Reg No. 36,119), Stephen C. Durant (Reg No. 31,506), Carolyn A. Favorito (Reg No. 39,183), David L. Fehrman (Reg No. 28,600), Hector Gallegos (Reg No. 40,614), Thomas George (Reg No. 45,740), Debra J. Glaister (Reg No. 33,888), Kenneth R. Glick (Reg No. 28,612), Johney U. Han (Reg No. 45,565), Douglas G. Hodder (Reg No. 41,840), Alan S. Hodes (Reg No. 38,185), Charles D. Holland (Reg No. 35,196), Peter Hsieh (Reg No. 44,780), Wayne Jaeschke, Jr. (Reg No. 38,503), Madeline I. Johnston (Reg No. 36,174), Richard D. Jordan (Reg No. 33,519), Parisa Jorjani (Reg No. 46,813), Ararat Kapouytian (Reg No. 40,044), Richard C. Kim (Reg No. 40,046), Cameron A. King (Reg No. 41,897), Kawai Lau (Reg No. 44,461), Rimas T. Lukas (Reg No. 46,451), Michael J. Mauriel (Reg No. 44,226), Gladys H. Monroy (Reg No. 32,430), Philip A. Morin (Reg No. P-45,926), Kate H. Murashige (Reg No. 29,959), Martin M. Noonen (Reg No. 44,264), Catherine M. Polizzi (Reg No. 40,130), Paul J. Riley (Reg No. 38,596), Debra A. Shetka (Reg No. 33,309), Terri Shieh-Newton (Reg No. 47,081), Rebecca Shortle (Reg No. 47,083), Kevin R. Spivak (Reg No. 43,148), Stanley H. Thompson (Reg No. 45,160), Michael R. Ward (Reg No. 38,651), E. Thomas Wheelock (Reg No. 28,825), Todd W. Wight (Reg No. 45,218), Frank Wu (Reg No. 41,386), David T. Yang (Reg No. 44,415), Peter J. Yim (Reg No. 44,417), George C. Yu (Reg No. 44,418), Karen R. Zachow (Reg No. 46,332)

Send correspondence to: Robert K. Cerpa
Morrison & Foerster LLP
755 Page Mill Road
Palo Alto, California 94304-1018

Direct telephone calls to: Robert K. Cerpa at (213) 892-5615

201	FULL NAME OF INVENTOR	FAMILY NAME FISCH	FIRST GIVEN NAME Eliezer	SECOND GIVEN NAME
	RESIDENCE & CITIZENSHIP	CITY Raanana	STATE OR FOREIGN COUNTRY Israel	COUNTRY OF CITIZENSHIP Israel
	POST OFFICE ADDRESS	POST OFFICE ADDRESS No. 15 Moshe Sne Street	CITY Raanana	STATE & ZIP CODE/COUNTRY Israel 43728
202	FULL NAME OF INVENTOR	FAMILY NAME FINK	FIRST GIVEN NAME Sagit	SECOND GIVEN NAME
	RESIDENCE & CITIZENSHIP	CITY Shoham	STATE OR FOREIGN COUNTRY Israel	COUNTRY OF CITIZENSHIP Israel
	POST OFFICE ADDRESS	POST OFFICE ADDRESS P. O. Box 4043	CITY Shoham	STATE & ZIP CODE/COUNTRY Israel 73142
203	FULL NAME OF INVENTOR	FAMILY NAME HAREL	FIRST GIVEN NAME David	SECOND GIVEN NAME
	RESIDENCE & CITIZENSHIP	CITY Rehovot	STATE OR FOREIGN COUNTRY Israel	COUNTRY OF CITIZENSHIP Israel
	POST OFFICE ADDRESS	POST OFFICE ADDRESS The Weizmann Institute of Science	CITY Rehovot	STATE & ZIP CODE/COUNTRY Israel 76100

204	FULL NAME OF INVENTOR	FAMILY NAME LANCET	FIRST GIVEN NAME Doron	SECOND GIVEN NAME
	RESIDENCE & CITIZENSHIP	CITY Rehovot	STATE OR FOREIGN COUNTRY Israel	COUNTRY OF CITIZENSHIP Israel
	POST OFFICE ADDRESS	POST OFFICE ADDRESS 15 Weizmann Street	CITY Rehovot	STATE & ZIP CODE/COUNTRY Israel 76280

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

SIGNATURE OF INVENTOR 201	SIGNATURE OF INVENTOR 202	SIGNATURE OF INVENTOR 203
DATE	DATE	DATE May 21, 2001
SIGNATURE OF INVENTOR 204		
DATE		